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THE UNIVERSITY OF ALBERTA

AN INVESTIGATION OF SPATIAL-TEMPORAL INFORMATION-PROCESSING IN CHILDREN WITH SPECIFIC READING DISABILITY

by

Ⓒ CHE KAN LEONG

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "An Investigation of Spatial-Temporal Information-Processing in Children with Specific Reading Disability" submitted by Che Kan Leong in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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TO

The LEONGS: Daphne, Laurence, Sonia
and their Mother
Theresa

Dr. John McLeod

ABSTRACT

The treatise is both a theoretical and empirical investigation of some psychological aspects of children with specific reading disability. Theoretical considerations including prevalence, contributing factors, relevant terms and concepts, heterogeneity of disabled readers and methodological problems provide a critical evaluation of current research into reading disability. The complex cerebral substrate subserving reading dysfunction as a language continuum is discussed and the importance of serial order involving an interchangeable system of spatial-temporal co-ordinates is emphasized. Two related major premises are suggested as central to the understanding of specific reading disability: functional cerebral development with the implicit hemispheric specialization, and spatial-temporal information-processing. The former postulate is verifiable via dichotic listening experiments with dichotic tapes made from a specially devised system of instrumentation. The latter postulate is tested through the mainly Luria-Das battery of tests tapping simultaneous-successive syntheses.

The two main postulates lead to an empirical investigation with an Experimental Group of 58 severely disabled readers compared with a Control Group of 58 above-average readers equated on age (9+), sex (boys) and ability level (average intelligence). Analysis of variance repeated measures results of dichotic listening experiment 1 using digits show that both the Experimental and Control Groups achieve an overall right-ear superiority with the latter surpassing the former group. Analysis incorporating series lengths of the digits further shows the main factors of group, half-span and series length are all significantly different. This finding of slightly poorer right-ear performance of the Experimental Group without implying that all disabled readers have better left-ear scores or that readers with better left-ear scores are necessarily at risk is taken as prima-facie evidence of a lag in functional cerebral development of this group. While the differential may be influenced by memorial factors, evidence tends to suggest the greater potency of perceptual asymmetry. An important finding from dichotic experiments 2 and 3 involving both digits and letters of the alphabet is the ineffective and inefficient use of strategies by disabled readers when they are specifically instructed to report dichotic materials by sides (left/right half-span) and types of stimuli (digits/letters). The differential use of strateiges finds further support in the correlational studies of 8 spatial-temporal tasks and with the dichotic sides and types tests added. Both principal component and alpha factor analyses demonstrate the statistical and psychological realities of the Luria-Das simultaneous-successive modes of information-processing. The invariance of the dimensions is upheld group-for-group, but not between groups, as verified with the Schonemann procedure. Two illustrative cases supplement findings relating to groups.

Summarizing, the postulate of functional cerebral development is found to be viable with suggestions for more refined experimentation. A

more flexible two-dimensional coordinate system of simultaneous-successive syntheses supported by reasoning from statistical, epistemological, psychological and neuropsychological sources is proposed as an alternative interpretation of the Luria-Das modes of information-processing. The cognizance of rules (linguistic awareness) and the development of strategies and processes are seen as basic mechanisms in the understanding of disabled readers.

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It has been said by Bruner that it is the lot of each investigator to live with his own demons. And so it is. The present investigation took me through what first appeared to be a tangled jungle, turned into an eighteenth century garden and finally the Garden of Delight. The "demon" that was in me rose at times to demonic (if not demoniac) heights in contending with intricately contrived creatures, some more fantastical than others, but all intelligible. Now that the Pierian spring is at hand, one can at least repose awhile and drink deep.

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PART I

THEORETICAL CONSIDERATIONS

CHAPTER 1

AN OVERVIEW

Reading maketh a full man ...

Francis Bacon

It has been said that there are as many dyslexics as there are dyslexias. The aphorism applies still more appositely to children--children with specific reading disability. Bacon's adage some 350 years ago that "reading maketh a full man, conference a ready man, and writing an exact man" holds with equal force today. Some 90 years after the "discovery" of dyslexia by Berlin we are still coming to grips with the perennial and vexed problem which is so large in scope and so complex in nature.

Even with the considerable body of knowledge which has accumulated in the area, there are still lacunae of research needs. The present investigation attempts to deal with what may be a tithe of some of these needs and is distinguished from similar studies in a number of ways. Very broadly, the investigation is at one and the same time a theoretical consideration of specific reading disability and empirical studies therefrom. Theoretical in that the inquiry embodies expositions and critical evaluations of relevant current work covering the last decade or so to late 1973 or early 1974, without forgetting "old" vintage such as Orton and Burt. Empirical in that both experimental and correlational approaches are used with fairly stringent experimental conditions to tap psychological processes with the former approach and with different tasks to study underlying products with the latter. Amidst facts from figures applied to groups, children as individuals are not lost sight of and individual difference is emphasized. The main thrust of the investigation is psychological with sources drawn from neuropsychology; experimental, clinical and educational psychology; and from speech perception as the information matrix. Though the study may be predicated on some viable theoretical paradigms and ongoing research studies, no one single school of thought is espoused. Instead, an eclectic or open view is sought so as to see the many-splendoured issues steadily and see them whole. These apparent contradistinctions--theoretical and empirical; group and individual; open and closed--may seem large claims. They are not so. If Occam's razor decrees that the law of parsimony should apply to all things, Occam's razor also dictates that the deceptively simple is often complex. An attempt is made here to unravel the complex.

Specifically, the treatise is a status inquiry into some psychological aspects of an experimental group of 58 nine-year-old boys with specific reading disability compared with an equal number of controls of above-average readers equated for age, sex and ability level. The investigation is predicated on two major premises: one is functional cerebral development and specialization and the other is spatial-temporal information-processing. The first premise is largely developmental (approached from a cross-sectional viewpoint) and the second is mainly cognitive with both premises converging on cerebral mechanisms subserving initial reading or reading dysfunction as a language continuum. The formulations of maturational lag in cerebral development verifiable through the dichotic listening paradigm and of inefficient information-processing strategies tested through correlational studies are seen as central to the understanding of children with specific reading disability. From the formulation of differential cerebral lateralization the postulates of lateralization effect for group, half-span and digit series length; of memorial and perceptual processes; of differential dichotic recall strategies by sides (ears) and types of stimuli are studied with 3 dichotic listening experiments. The formulation of simultaneous-successive syntheses is tested with a battery of "non-reading" tasks in two correlational studies with different methods of analyses and verification of invariance to explore psychological structures. The parallel but related dichotic experiments and correlational studies are buttressed with case illustrations. The findings on functional cerebral development are discussed and the realities of the simultaneous-successive syntheses affirmed and re-interpreted. An explanation of maturational lag in functional cerebral development and inefficient spatial-temporal information-processing may be found in the understanding and use of strategies (alternatives) and tactics (methods) by children to operate on what Luria calls "concrete-active" and "verbal-logical" tasks. A system of elementary operations in the "brains and machines" analogy is seen as the central mechanism for the understanding of children with specific reading disability.

The treatise is organized into three parts. Part I discusses relevant theoretical issues; Part II reports on the results and discussions, first singly and later in concert, of the three dichotic listening experiments and the two correlational studies together with case illustrations; Part III advances an alternative interpretation of simultaneous-successive syntheses and stresses the importance of rules and operations in information-processing. While each part with the different chapters forms an entity, the materials are often organized in a cyclic order with earlier expositions leading on to later ones and subsequent deliberations enlarging on preceding assertions so as to clarify and reinforce them.

The first 4 chapters together make up Part I. Very briefly, the present chapter presents an overview of the investigation. Chapter 2 on psychological aspects of reading difficulties discusses prevalence; factors--socio-cultural, bio-medical--affecting reading and its difficulties and some current terms and concepts. The term "specific reading disability" is seen to be the more appropriate and the heterogeneity of disabled readers is stressed. A glance at dyslexia and aphasic patients using ideographic and syllabary languages shows some prima facie evidence of differential cerebral processing of ideograms and phonograms. The current state of the Art of specific reading disability is critically reviewed. The research parameters of identifying reading performance of the disabled readers at the initial stage of reading; of careful sampling of children and appropriate research designs are stressed. Initial reading as a language continuum is related to linguistic awareness with spelling-to-sound invariants and reading dysfunction is related to the major premises of functional cerebral development and information-processing.

Chapter 3 discusses the complex cerebral substrate subserving the language continuum including initial reading. Geschwind's structural view emphasizing cross-modal associations of the brain and Luria's complex cerebral functional systems are explained. These mechanisms together with the view of focal and diffuse representations in the hemispheres provide a clue to a better understanding of cerebral dominance. Orton's theory of strephosymbolia is revisited and partly vindicated from split-brain experiments. The role of auditory perception in cerebral specialization relates to the differential strengths of ipsilateral and contralateral neural pathways. With the actual or latent contribution of the "lesser" hemisphere, the "complementary-different" relationship between the hemispheres in humans is emphasized.

Chapter 4 begins with the "brains and machines" analogy. Lashley's serial order and Luria's simultaneous-successive syntheses are explained and commented on. These mechanisms together with temporal order perception underpin reading dysfunction and are seen as involving an interchangeable system of spatial and temporal coordinates. Studies of reproductive serial order lead to the dichotic listening experiments while studies of simultaneous synthesis (primarily spatial elements) and successive synthesis (primarily temporal series) lead to factor analyses of simultaneous-successive information space.

Part II "An Investigation" consists of Chapters 5, 6, 7, 8 and 9. Chapter 5--"a principal component" of the investigation--discusses in depth the dichotic listening paradigm from both psychological and speech perception literature. The theoretical models of dichotic listening--Broadbent's filter theory and Kimura's perceptual model with its variants--are explored and commented on. Ongoing molecular studies emanating mainly from the Haskins Laboratories relating to differential perception of speech stimuli, lag effect and their effect on speech lateralization are discussed. There is a paucity of information on technical problems in dichotic tape preparation such as the achieving of synchrony and rates of presentation of stimuli. The experiment carried out by the writer in dichotic tape preparation is described in detail. The system of instrumentation involves the use of two matched dual-channel tape recorders and a specially designed and constructed control device. Onset synchrony and inter-stimulus interval are verified with great precision with the innovative use of the polygraph machine. The system together with quality control is considered superior to what there is reported in the literature.

Chapter 6 details the formulations and hypotheses pertaining to the two "subroutines" of the main "programme"--functional cerebral development and simultaneous-successive syntheses. Sampling is discussed at some length under two headings: general considerations of status studies of equivalent groups and attendant methodological problems and the specific procedure in selecting the 58 disabled readers and their controls in 16 different schools. The materials for the 3 dichotic experiments and the 8 main simultaneous-successive tasks are described and commented on to provide some insight into the nature of these tasks and the possible strategies for their successful performance. The chapter also sets forth the administrative arrangement in conducting the studies in situ in 16 different schools with the 116 children.

Chapter 7 reports on the detailed analysis of variance (repeated measures) results of the 3 dichotic listening experiments. The testing procedure and "ear order" and "attempted ear order" scoring are discussed. The performance of the Experimental and Control groups related to various aspects of cerebral lateralization is discussed. This includes the relative contribution of memorial and perceptual processes; differential use of recall strategies by "sides" (ears) and "types" of stimuli; and recall by digits and letters of the alphabet. Appropriate inference is drawn on functional cerebral development as it relates to disabled readers.

Chapter 8 aims at studying the dimensions underlining some "non-reading" tasks in the disabled and non-disabled readers. The chapter reports on the detailed results of two group-for-group correlational studies: one involving a battery of 8 spatial-temporal tasks and the other battery with the addition of dichotic sides and types tasks, making a total of 10 variables. Both the principal component and alpha factor analyses are used throughout for each group with the Schonemann procedure of factor matching for more "method-independent" and meaningful results.

To reconcile the "towards uniqueness" and "towards generalization" approaches, Chapter 9 presents 2 illustrative cases with information from early developmental history and stresses the importance of N = 1 studies.

The theoretical consideration in Part I and the empirical investigation in Part II are integrated in Part III. Chapter 10 provides general discussions of the investigation as a whole. It begins with self-criticisms of the research design, sampling and tasks used in the studies and offers suggestions for an even better experimentation. The role of research into reading dysfunction is re-affirmed with specific mention of contribution from research findings to the now discredited "whole-word" approach to teaching initial reading; reversal errors of disabled readers and the importance of linguistic awareness. The postulate of maturational lag in cerebral development is further considered in the light of experimental results as being compatible with theories of child development and neuropsychological findings. The realities of the Luria-Das simultaneous and successive modes of information-processing are confirmed and re-interpreted as a more flexible two-dimensional coordinate system of simultaneous-successive syntheses. The alternative interpretation is based on reasoning from statistical, epistemological, psychological and neuropsychological sources. The development of strategies and the use of tactics in information-processing is seen as basic mechanisms in the understanding of children with specific reading disability.

Chapter 11 entitled "Retrospect and Prospect" summarizes the gist of the investigation and also looks forward to still more lacunae for research.

To recapitulate the sequence of operations of the various chapters outlined above, the main "programme" and the two "subroutines" are flow-charted in Figure 1-1.

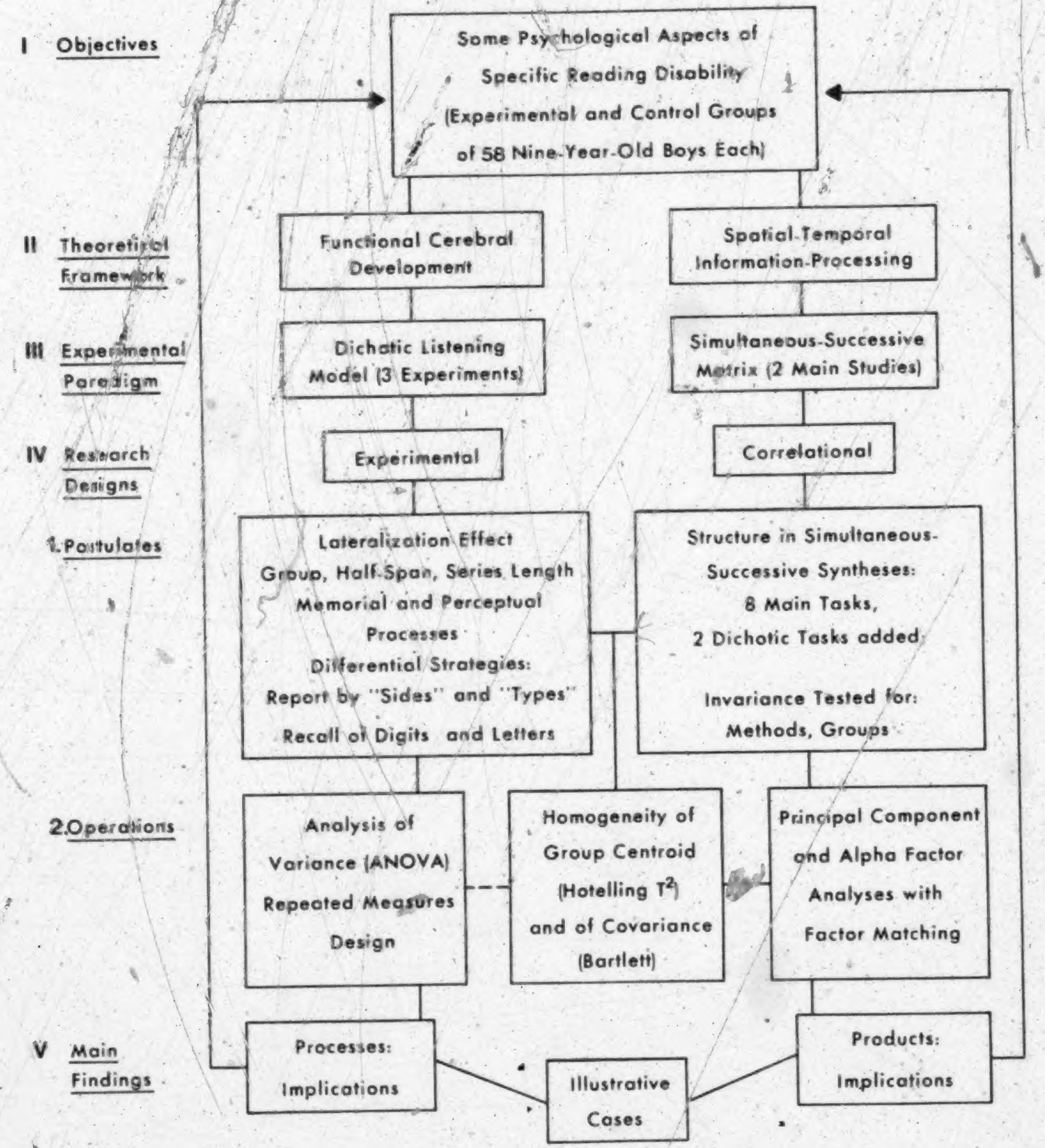
I Objectives
II Theoretical Framework
III Experimental Paradigm
IV Research Designs
1. Postulates
2. Operations
V Main Findings
Some Psychological Aspects of Specific Reading Disability (Experimental and Control Groups of 58 Nine-Year-Old Boys Each)
Functional Cerebral Development
Spatial-Temporal Information-Processing
Dichotic Listening Model (3 Experiments)
Simultaneous-Successive Matrix (2 Main Studies)
Experimental
Correlational
Lateralization Effect
Group, Half-Span, Series Length
Memorial and Perceptual Processes
Differential Strategies:
Report by "Sides" and "Types"
Recall of Digits and Letters
Structure in Simultaneous-Successive Syntheses:
8 Main Tasks,
2 Dichotic Tasks added
Invariance Tested for:
Methods, Groups
Analysis of Variance (ANOVA) Repeated Measures Design
Homogeneity of Group Centroid (Hotelling T^2) and of Covariance (Bartlett)
Principal Component and Alpha Factor Analyses with Factor Matching
Processes: Implications
Illustrative Cases
Products: Implications

Figure 1-1 Flowchart of main "programme" with "subroutines"

CHAPTER 2

PSYCHOLOGICAL ASPECTS OF READING DIFFICULTIES

> And reading itself, as a psychophysiological process is almost as good as miracle . . . And so to completely analyse what we do when we read would almost be the acme of a psychologist's achievements, for it would be to describe very many of the most intricate workings of the human mind.
>
> Edmund B. Huey. The Psychology and Pedagogy of Reading. (1908, reissued, 1968.)

It is instructive to read Huey's masterpiece The Psychology and Pedagogy of Reading (1968), first published in 1908, and to find that there is still much to be learnt about the reading process. Huey knew more than 60 years ago about the eye-voice span; he knew about eye-movements and right-left laterality on the retina; he knew that a five-letter word could be read with as short a duration as a single letter. He said that "consciousness is not a picture-gallery, or a magic lantern exhibition with slide desplacing slide in rapid succession." (p. 60). He thought consciousness (and reading) as immediate experiences were a search for meaning. All these experimental results and much more have been taken up with vigour by researchers and practitioners since then. Today a considerable body of knowledge has accumulated on the reading process and on reading dysfunction. It is the latter condition in children that this investigation is mainly concerned with.

2.1 Prevalence of Reading Difficulties

It was thought at one time that reading difficulties, like poverty, would not always be with us. While abject poverty is largely eradicated in developed countries and opportunities for education are more or less equalized, the problem of reading difficulties, as gleaned from studies on both sides of the Atlantic, does not seem to diminish. In England the 1956 Ministry of Education Survey of Reading Standards reported that some 25 percent of school leavers could be classified as "backward readers," "semi-literate" or "illiterate." Morris in 1954 found about 19 percent of children entering the British junior school could scarcely read at all and that about half of those who were severely backward at 7-8 years would still be backward on leaving school at 15 years of age (Morris, 1959). In another careful study, she found that for eight-year-olds 14 percent of a sample of school children were reading not at all or extremely poorly and that half of them remained very poor readers throughout secondary school (Morris, 1966). Kellmer Pringle, Butler, and Davie (1966) reported that 18 percent of 11,000 children entering the junior school were poor readers and 9.8 percent were non-readers. In the U.S.A. the functional illiteracy rate is estimated to be as high as 25 percent (Allen, 1971). The Director of the Right to Read programme suggests a figure of 18.5 million functionally illiterate adults and some 7 million elementary and secondary school children as reading at least two grades below their ability (Holloway, 1971). In Scandinavian countries, Hallgren (1950) estimated 10 percent of Swedish school children and Hermann (1959) provided a similar figure of 10 percent of Danish students as having reading difficulties. While terminologies and criteria defining reading difficulties differ, there is considerable consensus that some 10 percent of the school population are backward in reading. This high prevalence figure is a cause for concern. It may of course be argued that poor readers can still get by in later lives in an era when information can be obtained from such media as the radio and television and that "the medium is the message." Whether this is a valid argument is more philosophical than psychological or educational in nature and is beyond the scope of this inquiry.

Within the broad group of reading retarded children or extending from them is a sub-group of disabled readers who make only slow progress in reading. The prevalence of this "hard-core" sub-group has been variously estimated. Myklebust and Boshes (1969) carried out an important study dealing with 2,767 grade 3 and grade 4 children from average socio-economic homes, who had been screened for ability (IQ 90+),visual difficulties, hearing difficulties and anxiety problems. Using a definition of achievement expectancy ratio of less than 85, the workers estimated 7.5 percent learning disability among these carefully screened children with a ratio of four boys to one girl. A more stringent figure of the sub-group is provided in the recent comprehensive Leadership Training Institute in Learning Disabilities Report commissioned by the U.S. Office of Education (Bryant and Kass, 1972). These workers estimate that when exclusions are made for visual, hearing, emotional disorders and environmental disadvantages, the prevalence of children with some learning disabilities is in the 5-15 percent range and that of hard-core cases is often ¼ to 1 percent and seldom exceeds 4 percent. This proportion of children with severe reading disability and an even larger one with reading difficulties prompt one to examine the multi-factors which affect reading or reading dysfunction.

2.2 Factors Affecting Reading and its Difficulties

There are two broad groups of factors making for reading difficulties. One group may be called extrinsic factors or factors outside the child. The other group may be called intrinsic factors or factors within the child. The two groups of factors act and interact on the individual exponentially. The interplay of factors is illustrated schematically in Figure 2-1.

2.2.1 Socio-Cultural Factors

Extrinsic or socio-cultural factors include home conditions, socio-economic status of parents, parental attitude towards education and aspirations for the child. Burt (1937), in his classic study of backwardness at the time, emphasized the plurality of adverse circumstances. He found that in more than 50 percent of cases of backwardness, there was what he termed "innate mental deficiency" together with correlates of unfavourable physical, home, school, social or temperamental factors. The most frequent and conspicuous factor was the lack of proper care by the mother--often the result of her own poverty and ill-health, and in a large number of cases, the outcome of her low intelligence. He also drew attention to the paucity of experiential background of backward children. Schonell (1942) pointed out that conditions within the home and the school were extremely important contributory causes of the child's meagre reading progress. Douglas (1964) found that achievement

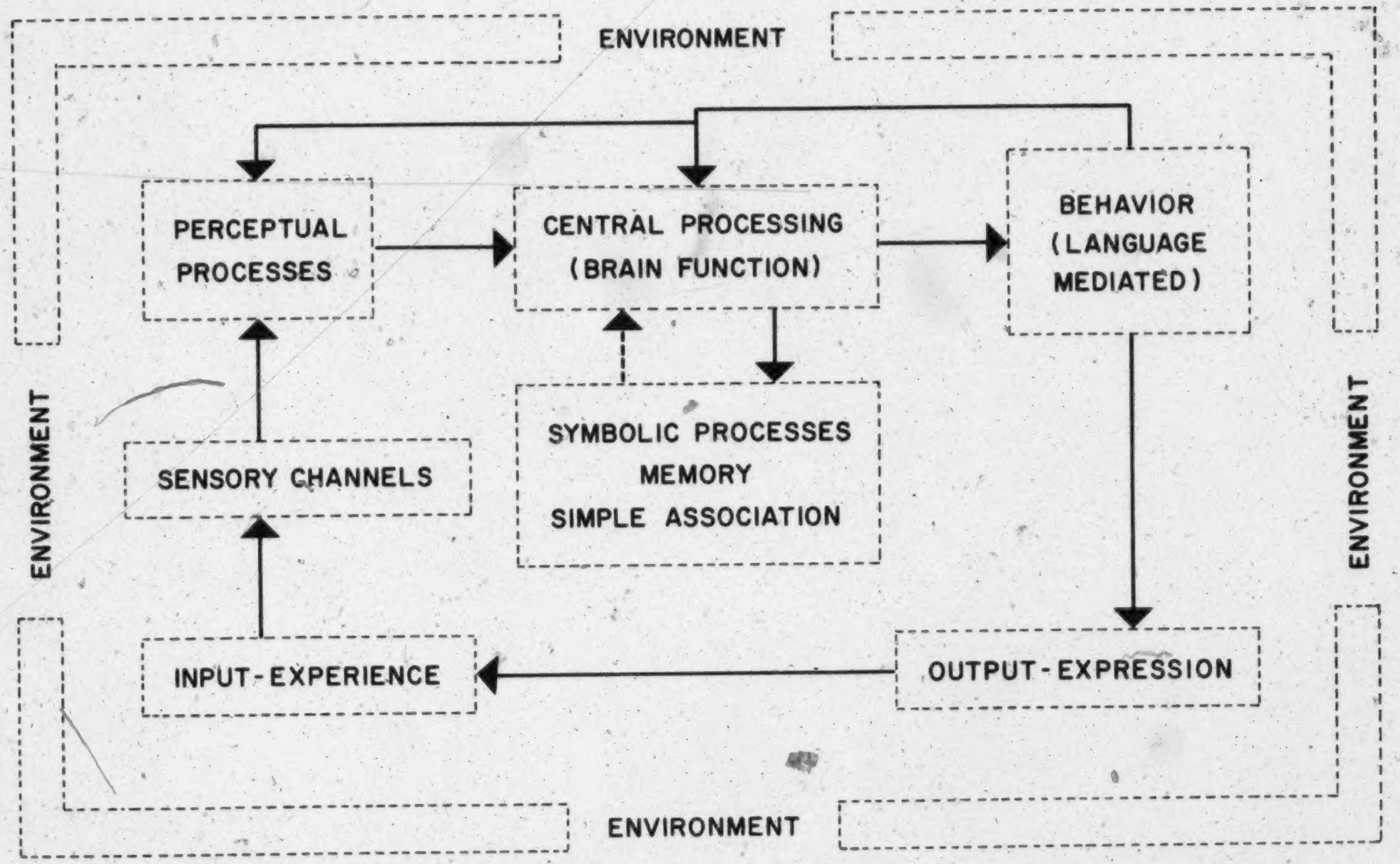
ENVIRONMENT
PERCEPTUAL PROCESSES
CENTRAL PROCESSING (BRAIN FUNCTION)
BEHAVIOR (LANGUAGE MEDIATED)
SYMBOLIC PROCESSES
MEMORY
SIMPLE ASSOCIATION
SENSORY CHANNELS
INPUT-EXPERIENCE
OUTPUT-EXPRESSION
ENVIRONMENT
ENVIRONMENT
ENVIRONMENT

Figure 2-1. Factors affecting reading and its difficulties.

in general and reading and vocabulary in particular were affected by a combination of environmental factors, viz., housing conditions, social class, parental encouragement, family size and primary schooling. Wiseman (1964) in his study of the attainment of fourteen-year-olds in the greater Manchester area found that factors in the home environment were overwhelmingly more important than those of the neighbourhood or the school. Of these home influences, factors of maternal care and of parental attitude to education were of far greater significance than social class and occupational level. Wiseman also emphasized that environmental influences on attainment had the greatest impact on the more able children. Wiseman (1968) further made the distinction between "educational deprivation" and "educational disadvantage" in referring to the lack of opportunity for education and the effect of the environment on attainment rather than opportunity.

Some time ago Bernstein (1961, 1964) hypothesized two linguistic codes or language systems pertaining to different socio-economic strata. Lower class children tend to use a "restricted" code or public language which is characterized by rigidity of syntax and "restricted use of formal possibilities for verbal organization." Middle class children tend to use an "elaborated" code or formal language which is varied in its syntactical structure, which allows for the communication of organized, logical sequences and is less predictable for any one individual who has a wide array of possibilities from which to select. Bernstein suggested that the educational backwardness observed in lower class pupils is a "culturally induced backwardness transmitted and sustained through the efforts of linguistic processing" and differs in dynamic form from the backwardness attributable to psychological factors. Cynthia Deutsch (1967) points out the "euphemism" of "disadvantaged" is used to convey a "categorization involving social or psychological variables" and that there are different kinds of learning and different kinds of disadvantage. For children coming from poor homes, life is a series of critical situations where food, housing, clothing and one's whole pattern of life may change without warning and where adults use physical punishment in an erratic way to maintain discipline. The child in turn is dominantly physical, rather than ideationally and verbally oriented. Language is used to control people more than to carry information. The manipulation of objects and people is more important than the manipulation of ideas or the transmission of information. More recently, there is greater recognition of the concept of cultural relativism and different "ethnic patterns" related to learning difficulties. Lesser, Fifer, and Clark, (1965); and Stodolsky and Lesser (1968) all stress the need to specify the environmental experiences "which are closely articulated with developmental processes and which vary considerably within and across social class and ethnic lines." Working within the same framework of family interactions and their resultant patterns of communication, Bernstein and Young (1966) have been investigating a "communication profile" which may complement or even replace social class as an independent variable in the study of cognitive behaviours of disadvantaged children. The regard for cultural or subcultural relativism in the context of learning disabilities may have a special place in a plural society such as that of North America.

* There are biological concomitants which expose people in lower socio-economic strata to greater risks of psycho-neurological disorders. Some of the bio-medical factors trace to the process of pregnancy and

reproduction, which can be hazardous. The term "reproductive casualty" or sometimes "reproductive wastage" is used to denote the sequelae of harmful events during pregnancy resulting in damage in the fetus or newborn infant and primarily localized to the central nervous system. Pasamanick, Kawi, and Lilienfeld (Pasamanick and Kawi, 1956; Pasamanick and Lilienfeld, 1955a, 1955b) described the existence of such a continuum of stress factors in a series of studies. Pasamanick and Knobloch (1966) reported the results of the relationship between prenatal experience and certain psychiatric disorders in more than 9,000 children. The disorders studied were: cerebral palsy, epilepsy, mental deficiency, behavioural disorders, reading disorders, tics, speech disorders, strabismus, hearing disorders, accidents in school children, autism, juvenile delinquency. Controls consisting of the next surviving infant in the birth certificate register of the same race, sex and socio-economic status born in the same hospital to a mother of the same age were selected. Reading disabilities was one of the five disorders found to be significantly associated both with complications of pregnancy and prematurity (determined by gestation period and birth weight). For the studies as a whole, Pasamanick and Knobloch suggest that abnormalities of pregnancy are associated with certain life experiences, usually socio-economically determined, and the resulting neuro-psychiatric disorders are found in greater aggregation in the lower strata of society. However, the researchers are quick to point out that the disorders must not be attributed to racial or social characteristics, as lower protein intake, malnutrition and poor health generally are more prevalent amongst the poor. They emphasize:

> . . . it seems more parsimonious to eliminate the postulated racial factor and to hypothesize that prematurity and pregnancy complication rate increase exponentially below certain socio-economic threshold.

They point out that the toxemias of pregnancy, placental disorders, prematurity, maternal fatigue and trauma, low protein intake and some non-specific acute and chronic infection are all heavily weighted in the lower socio-economic strata of any population in the development of non-fatal neurologic damage including reading disabilities. They say, ". . . these variables almost certainly operate multifactorially, each tending to aggravate that of the other." It is important to grasp this complex of exogenous environmental noxious agents with their sequelae acting and interacting along an organic-functional axis. Even the United States with all its affluence leaves a great deal to be desired in the provision of health care for children. Wortis (1965, p. 893-894), who is noted for his work on mental retardation, sounded the alarm in 1965 that the U.S.A. was ". . . eighth in the world in perinatal mortality, seventh in congenital malformation, and ninth in the world in infant mortality rate. . ." and that the U.S. had ". . . the worst record for infant death due to birth injury, post-natal asphyxia, a rate twice as high as Norway. . ." Across the Atlantic, Walker (1966) draws attention to "the valley of the shadow of birth" with concomitant hazards in the birth process. Quoting studies in Aberdeen and Dundee in Scotland, Walker points out that children with low standards of living and poor nutrition are:

> . . . neither conceived nor born 'equal': they also have the poorest maternal intrauterine environment, the poorest pregnancy and labour care, the poorest post-natal opportunity, the poorest environment in which to grow and develop and the highest infancy illness. Maternal iron deficiency, folic

> acid deficiency, specific protein deficiency, poor heart volume, and maternal infection are all measurably more common.
>
> (p. 112-113)

If the warnings by Pasamanick et al, Wortis and Walker sound alarming in developed nations, it is even more alarming in developing and under-developed countries. Lest the dire warning sounds too pessimistic, it should be pointed out that sometimes nature has a way to compensate for deficiencies. In communities with inadequate and poor services probably many infants often adapt themselves to combat situations potentially dangerous to themselves. Some babies, however, by virtue of pre-existing genetic malconstitution or because of some intrauterine deficiency, are less able to cope with insults that others can surmount. These stress factors leave their mark in the intelligence and achievement of the children affected. There is a paucity of longitudinal studies on insults before, during, and after birth and the ability of individuals to cope with these insults at different times in developing countries. More is needed to improve the nutritional status and care of both the mother and the child. This extended care will no doubt improve on achievement and perhaps intelligence.

2.2.2 Mental Abilities

Within the cultural, familial context, there are intrinsic factors which operate within the child to affect his total functioning in the school situation. One factor is intelligence. The small number of children who are at the low end of the continuum of intelligence or who are low in intellectual functioning because of pathological reasons will have difficulty in reading. For the majority of children who are low in intelligence, early intervention and suitable treatment can do much to help them. It is beyond the scope of this treatise to discuss nature-nurture interaction or the relationship between the phenotypes and genotypes continuum except to say that studies of twins have attested to a genetic influence on phenotypic measures of intelligence. Thus the correlations of test scores between monozygotic or identical twins are higher than those between dizygotic twins or siblings or those between parents and children, which, in turn, are higher than those between cousins, and those between first cousins are somewhat higher than those between second cousins or unrelated children reared apart. It is, however, difficult to say how great the genotypic influence is. Estimates of heritability which is defined as that proportion of the variance within a specific population in the phenotypic measure of a characteristic that is determined by the genotypic variation between that population show about three-quarters of the variance as due to genetic components (Burt, 1966, 1972; Burt and Howard, 1956, 1957; Huntley, 1966; Jensen, 1969). On the other hand, Hunt (1961, 1969) brings together evidence to show the fallacy of these long-held notions: fixed intelligence, predetermined development, static telephone switchboard nature of brain function and the unimportance of pre-verbal experience in early years. He emphasizes the importance of pre-school enrichment as an antidote for cultural deprivation. More recently, he has reiterated that indices of heritability are relevant only to the status quo within a given population in a relatively static environment and the interpretation of heritability indices is dissonant with the plasticity and educability of young children (Hunt, 1973). Bloom (1964) is often quoted for his view that deprivation in the first four years of life can have far greater consequences than at any later period. A balanced view is given by Hebb (1949, pp. 302-303) some time ago and which is still valid:

> There are then two determinants to intellectual growth: a completely necessary innate potential (intelligence A), and a completely necessary stimulating environment. It is not to the point to ask which is more important: hypothetically, we might suppose that intelligence will rise to the limit set by heredity or environment, whichever is lower. Given a perfect environment, the inherited constitution will set the pace; given the heredity of a genius, the environment will do so.

It may be of interest to recall that Binet recognized the influence of experience on tested intelligence.

> We do not measure the intelligence considered separately from a number of concrete circumstances--the intelligence which is needed for understanding, for being attentive, for judging. It is something far more complex that we measure. The result depends: first, on the intelligence pure and simple; second, on extra scholastic acquisition capable of being gained precociously; third, on scholastic acquisitions made at a fixed date; fourth, on acquisitions relative to language and vocabulary, which are at once scholastic and extra-scholastic, depending partly on the family circumstances.
>
> (Binet and Simon, 1916, pp. 258-259.)

Educators and social scientists probably would like to regard genetic inheritance, over time, as one more environmental factor capable of being controlled. It may not be just wishful thinking that in the world of scientific marvels to come that we can ultimately manipulate these variables.

The educability of intelligence should be considered along with its distribution. The ubiquitous normal probability curve can be a statistical artifact (Dingman and Tarjan, 1960). Masland (1970) and Parker (1971) have hypothesized multiple distribution of mental abilities as shown in Figure 2-2. The acceptance of a number of curves instead of a single curve for the distribution of general ability will make test

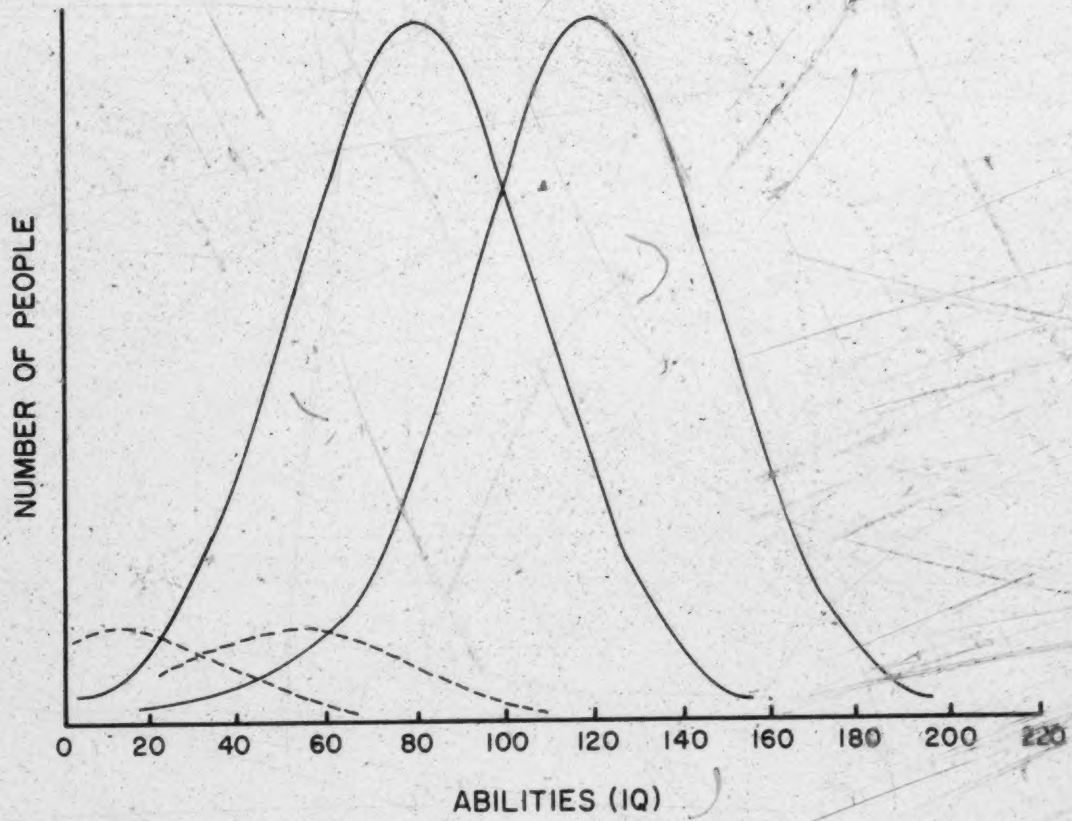

Figure 2-2. Hypothetical distribution of mental abilities as profiles (after Masland, 1970; Parker, 1971).

constructors more conscious of the need to sharpen their instruments for more refined discrimination. It will also emphasize the fact that within a given ability range, there is a mixture of types of individuals with different strengths and weaknesses. The level of, say, IQ 85 to 115, will include the average individuals of the population and, in addition, a number of individuals whose IQ should be higher but whose performance is impaired by some specific disabilities. This concept of multiple distribution of abilities is similar to the concept of mental profiles of children proposed by Thurstone (1948). Thurstone emphasizes that mental abilities are functionally distinct and that the different primary factors grow and mature at different rates. Thurstone (1955) fitted Gompertz equations to longitudinal and cross-sectional data on the growth of special mental abilities from ages one to nineteen and the results show a marked differential growth rate for the selected mental abilities. As an example, perceptual and spatial abilities reveal an earlier ontogenetic development whereas verbal abilities reveal a later and a slower development with age. The implication for teaching is that methods of instruction should be adjusted to the mental profiles of children. This approach via profiles finds confirmations in recent theoretical and experimental work based on the Osgood-Kirk-Wepman modality concept. There may be audiles and visiles in reading and that some children have difficulties in integrating spatial and temporal elements which are so essential to successful reading (Wepman, 1962).

2.2.3 Inborn Errors and Other Factors

There are also inborn errors of central origin impinging on the initial reading process. Leong (1972a, 1973b) has discussed some of the correlates of reading disability. Lenneberg (1964) has proposed a biological foundation for language and hypothesized that language might be the cause rather than the result of intelligence. His pious hope that chromosome studies be carried out amongst at-risk families is fast becoming a reality when it is now possible to computerize chromosome karyotyping (Pensom, 1971). There may be an appreciable number of undetected individuals who have mild forms of chromosomal aberrations and yet who can function adequately in society. As an example, individuals with Turner's Syndrome (incidence estimated at 1 in 3,000 live births) may range from mildly through moderately to severely retarded. They tend to be low in non-verbal IQ but score from average to even high in verbal IQ. They have form-discrimination dysgnosia as found in the perceptual organization subtests of the Wechsler and the Bender Gestalt, and directional-sense disability and may also have reading disability (Money, 1966, 1967). For individuals with Klinefelter's Syndrome (with incidence of mental retardation estimated at 1 in 4 and about 1 in 100 male retardates demonstrating this syndrome), Money (1964) found a full range of Wechsler IQ's among a sample of 23 patients with no significant verbal and performance discrepancy but a tendency beyond the normal for congenital dyslexia and apraxia for the spoken language. In another aspect of the physiological correlate of learning disability Dykman, Ackerman, Clements, and Peters (1971) carry out longitudinal studies of four interrelated components of attentional deficits in learning-disabled children: alertness, stimulus selection, focusing and vigilance. Working within the Luria (1959, 1961) framework of cerebroasthenic syndrome of excitatory and inhibitory individuals, Dykman and co-workers distinguish two main types of learning-disabled children: the hyperactive who appear to be distractible and over-attentive to their environment and the hypoactive who are under-attentive with about the same net effect on learning. While these researchers acknowledge that evidence for defective attentional mechanisms in the learning disabled is indirect, there is a considerable body of literature to support their viewpoint (Chalfant and Scheffelin, 1969; Myklebust, 1954; Senf, 1969; Senf and Freundl, 1971; Strauss and Lehtinen, 1947). Drawing on his empirical work on attention of the mentally retarded, Das (1973c) recently also discusses the learning disabled in terms of Luria's excitation-inhibition balance.

In the field of visual perception both Orton (1943) and Tinker (1936) denied some time ago the significance of eye movements in the aetiology of reading disorders. In a classic paper the ophthalmologist Goldberg (1959) called for greater cooperation between ophthalmologists and educators in the remediation of disabled readers. He clearly stated that defective vision, muscle imbalance and strabismus are not significant factors in dyslexia and that convergence insufficiency and a weak binocular status may cause fatigue and slow reading, but will not retard it. Critchley (1964, p. 40, 1970, pp. 50-64) believes that dyslexia is independent of error of refraction, muscle imbalance, and imperfect binocular fusion but adds the qualification that subtle ocular examinations might uncover certain defects although these defects could be the product rather than the cause of dyslexia. Vernon (1957) could not find in her cases of slow or retarded readers evidence of general disorder of the visual perception of shape. She contends that whatever deficiency in the accurate discrimination of detail and of spatial orientation might have been the result, rather than the cause, of reading disability. More recently, the American Academy of Pediatrics, the American Academy of Ophthalmology and Otolaryngology and the American Association of Ophthalmology issued a joint organizational statement (January, 1972) on "the eye and learning disabilities." These organizations state categorically that ". . . there is no peripheral eye defect which produces dyslexia and associated disabilities. Eye defects do not cause reversals of letters, words, or numbers." Deploring the claims of improving the academic skills of disabled readers with treatment based solely on ocular training and neurological organization training, these learned bodies recognize that remediation is the ultimate responsibilities of educational science and that "no one approach is applicable to all children." In the last analysis it is not the eye that reads but the brain.

The discussion above makes it clear that reading difficulties cannot be attributed to a single cause. The condition is the result of a constellation of causes acting in a multi-factorial way on the individual child. The different combinations of factors acting and interacting at different stages of the child's development contribute to varying degrees of severity of reading difficulties. The various shades of disabilities will be operationally defined in the next section.

2.3 Terms and Concepts

As in other emerging fields of the science of education the terms employed in the area of reading difficulties are legion and do not always carry the same meaning. It is therefore important to attempt a clearer delineation of some of the terms commonly used in the literature.

The term "reading difficulties" is generally used to refer to that broad group of children--the proverbial 10 to 15 percent of the school population--who are deficient in reading. In this context it should be noted that Vernon in her 1971 book on the subject favours the same term "reading difficulties" rather than "reading backwardness" used in her earlier book (Vernon, 1957). At the tail-end of this broad group of backward readers or more probably extending from the continuum is a subgroup of severely disabled readers. These children have been variously labelled, so much so that Dunn (1967) deplores the subsequent confusion created and Reger, Schroeder, and Ushold (1968) deride what borders on fragmented preparation and certification needed for teachers to teach the apparently discrete though integral group of "perceptually handicapped," "neurologically damaged," "hyperkinetic" children and the like. The unresolved difficulty of "what shall the thing be called" and "whom shall it include" partly stems from the complexity of the condition itself. It also stems from the fact that different disciplines approach basically the same problem from different vantage points. Pediatricians, neurologists and ophthalmologists--historically the first to study the problem--are more concerned with aetiology and associated symptoms, whereas educators are more interested in the pragmatics of remediation. Hence the apparent "terminological inexactitude."

The publication in 1966 of NINDS Monograph No. 3 Minimal Brain Dysfunction in Children (Clements, 1966) goes a long way towards clarifying nomenclature for mutual understanding by various professional groups. After extensive review of the literature to the mid-1960's the

Monograph lists 37 extant terms together with their symptomatology. Of the 37 terms listed, these six are more inclusive and less susceptible to misinterpretation: "minimal brain dysfunction," "learning disabilities," "dyslexia," "psychoneurological learning disorders," "reading backwardness/reading retardation," and "specific reading disability." A brief comment on each is offered below.

The term "minimal brain dysfunction" is generally used by medical practitioners. It steers itself clear from the circular misconception (see Birch, 1964) of structural brain damage and denotes a mild, subclinical form of central dysfunction which manifests itself in varying degrees of severity and which subtly affects learning and behaviour. Various combinations of impairments are shown in perception, conceptualization, language, memory and attention and similar symptoms may or may not complicate the problems of children with such disabilities as mental retardation, emotional disturbance or cerebral palsy. Very recently, Benton (1973) argues from his long experience in neuropsychology that major rather than minimal brain dysfunction should be assumed as being responsible for the symptom-complex. He further points out directions for neuropsychological investigation including objective definition of the signs of minimal brain dysfunction, syndrome analysis, critical study of personality deviations and evaluation of the influence of interactive factors.

In contradistinction to the medically oriented minimal brain dysfunction is the term "learning disabilities" introduced in the early 1960's. The term highlights the educational aspect of the condition and the multi-faceted difficulties faced by the child, but suffers from the very broad connotation of all kinds of learning problems.

The term "psychoneurological learning disorder," not dissimilar to the "inborn reading disorders of central origin" of Critchley in his 1961 Doyne Memorial Lecture (Critchley, 1964), is proposed by Myklebust and associate (Johnson and Myklebust, 1967; Myklebust, 1971). The Johnson and Myklebust term is more precise than many, although it is rather involved. It has the merit of indicating that such disabilities are the psychological concomitants of neurological deficits. The frame of reference is the semiautonomous or interrelated systems of brain function and organization and the manifestation is psychological. Myklebust (1971, p. 3) further points out that the psychoneurological model also assumes that the brain serves as a transducer, so that one type of information can be converted into another and that brain dysfunction can affect a given type of learning more than others. While the concept embodied in the term psychoneurological learning disorder is embracing, the "objective statistical procedure" that Myklebust uses in evolving a Learning Quotient (L.Q.) leaves a great deal to be desired. The notion of L.Q. in each area of learning is not dissimilar to the "reading index" of Monroe (1932). The quotient is a ratio obtained by dividing various achievement scores by an Expectancy Age of the child, which is the mean of the aggregate of (Mental Age + Life Age + Grade Age) and an arbitrary Learning Quotient of 89 is taken as the cutoff. Thus the L.Q. suffers from all the inherent statistical weakness of comparing a ratio with another ratio, without mentioning the discrepant errors of measurement in each test. Similar methods in predictive studies have been the subject of criticisms in the distant past (Burt, 1959; Crane, 1959) and recent past (McLeod, 1968a, 1968b). Some 10 years ago Thorndike (1963) argued convincingly that the only satisfactory way of defining "underachievement" is through the use of regression techniques as discrepancy of actual achievement from the predicted value predicted on the basis of the regression equation between aptitude and achievement. Thus while the concept of psychoneurological learning disorders is sound psychologically, the associated learning quotient is weak statistically.

In the specific field of reading considered within the language continuum, the term "dyslexia" has an historic ring. Critchley (1964, p. 2) traces its origin to Professor Berlin of Stuttgart in the latter's monograph in 1887 Eine besondere Art der Wortblindheit (Dyslexia). A sketch of the biographical background of Berlin and his concept of dyslexia is provided by Wagner (1973). This term is preferable to Hinshelwood's "congenital word blindness" in 1917 as "word deafness" is just as relevant, or even more so, in reading dysfunction; and also to Orton's (1925, 1937) "strephosymbolia" or twisted symbols. From the neurologist's standpoint, Critchley (1964, 1970) discusses developmental dyslexia within the "aphasiological context." His account of concepts and terminologies is thorough and supported by clinical examples. He suggests these premises for the existence of developmental dyslexics who are nosologically apart from the continuum of poor readers:

> . . . persistence into adulthood; the peculiar and specific nature of the errors in reading and writing; the familial incidence of the defect; and the frequent association with other symbol-defects.
>
> (Critchley, 1964, p. 11)

This may be compared with the definition of specific developmental dyslexia at a meeting of the World Federation of Neurologists' Research Group on Dyslexia and World Illiteracy held in Dallas, Texas in April, 1968:

> A disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and socio-cultural opportunity. It is dependent upon fundamental cognitive disabilities which are frequently of constitutional origin.

Etymologically, the term "dyslexia" is as innocuous as any. It simply means hard or difficulty with "lexikos" or words--words seen, words heard, words spoken, words felt and even words internalized. When qualified, "developmental dyslexia" as contrasted with acquired dyslexia denotes a form of developmental lag more characteristic of children in the course of their acquisition of the spoken or read language. Thus the denunciation of the term and concept from some quarters is not warranted. The slings and arrows of outrageous fortune inflicted by professionals on "developmental dyslexia" range from rejection (e.g., Morris, 1966) to skepticism (e.g., Harris, 1968). Steadfast faith in the reality of the condition is maintained over the decades by those groups of neurologists, psychologists and educators with interdisciplinary perspectives on reading difficulties. One such group is the Orton Society. The Society, however, makes it clear that the breadth and specificity of the syndrome may require many names to describe and that "dyslexia" can be no more than an explanatory term. Some belated recognition is accorded to the syndrome by the International Reading Association (IRA) as witnessed its 1972 best media reporting award to the Baltimore Evening Sun for a nine-part series on dyslexia. In the U.S.A. Public-Law 91-230 entitled "The Elementary and Secondary Education Act Amendments of 1969: Title VI, The Education of the Handicapped Act" makes provisions for dyslexics as an identifiable group.

In Britain, skepticism has also gradually given way to cautious acceptance and experimentation. It should be noted that no less an authority than Vernon, who eschewed the concept of dyslexia in her 1957 book Backwardness in Reading, came round to the condition in 1962 (Vernon, 1962). In her 1971 book Reading and its Difficulties, she regards the problem of "specific developmental dyslexia" as a perennial one requiring further experimental and clinical investigation and devotes 50 out of the total of 180 pages in the book to the subject. Not only this, the condition is recognized in special clauses in the country's Chronically Sick and Disabled Persons' Act of 1970, which enjoin local education authorities to make special provisions for dyslexics. From Berlin's pioneer work in 1887 to the present date the wheel seems to have come full circle.

Still, the term reading backwardness or reading retardation adopted by earlier workers as Burt (1937), Schonell (1942) is generally preferred amongst British researchers. In their recent monumental Isle of Wight survey Rutter, Tizard, and Whitmore (1970) distinguish between the two concepts. Backwardness in reading accuracy or comprehension is defined in terms of 28 months or more below chronological ages (CA). Specific reading retardation is taken to mean attainment in reading accuracy or comprehension at 28 or more months below the level predicted on the basis of a child's age and short WISC IQ. A multiple regression equation is offered for predicting reading comprehension:

> -23.44 + (1.15 x short WISC total Scaled Scores) +
> (0.79 x CA in months) with a standard error of
> measurement of 14.95 months (Yule, 1967)

This approach to the classification of children with reading difficulties overcomes statistical objections inherent in achievement quotients, as raised by Crane (1959). The regression formula further has the effect of making adjustments relative to the WISC IQ. For example, a boy 9 years

9 months of age with a scaled score of 54 on the WISC short form scoring 8 years 10 months on the comprehension part of the Neale Reading Test (Neale, 1958) apparently is retarded in reading by 11 months, but adjustment in relation to his WISC IQ shows his expected reading age at 10 years 10 months. Another boy aged 10 years 6 months with WISC scaled score of 36 (WISC IQ 83) reading at the same level (8 years 10 months) shows less discrepancy statistically as his expected reading age is 9 years 10 months (Rutter, Tizard, and Whitmore, 1970, p. 35). Admittedly, there are flaws in the arbitrary 28 months or below cutoff; in the use of the WISC short form and in equating reading accuracy or comprehension solely on the basis of the Neale Reading Analysis Test. Overall, the regression approach is generally sound and may be the only statistically acceptable one. Thorndike (1963) has been emphatic in pointing out prediction studies of underachievement fall short because of: error of measurement; heterogeneity of criteria; limited scope of prediction and the impact of varied experience on the child. He stresses the need for cross-validation on new sets of data and the use of the correlation ratio "eta" rather than the usual Pearson product-moment correlation.

The orthodox concept of under-achievement and over-achievement thus needs re-examination. The unrepentent argument of Burt (1937, 1967) that over-achievement is a rare phenomenon is untenable. That over-achievement is as frequent as under-achievement is shown pragmatically by McLeod (1968a, 1968b). This is verified in elegant regression studies by Yule, Rutter, Berger, and Thompson (1974) in four replications in different populations and different age groups with sample sizes ranging from 1,143 to 2,113. The now discredited dogma that reading achievement should exactly parallel tested intelligence and the positive findings of as many "under-achievers" as there are "over-achievers" have implications for provisions and remediation of disabled readers. This finding also reminds us of the different abilities (Figure 2-2) underlying reading and reading difficulties. If a caveat may be entered against the fine-grained actuarial selection as contrasted with a clinical one at all, it is that exact statistical demarcation tends to lead one to neglect a problem when it is a problem.

Compared with the five foregoing names, the term "specific reading disability" as used by Eisenberg (1966), Hermann (1959), Doehring (1968) has a great deal to recommend itself. Hermann (1959) explains the disability thus:

> . . . a defective capacity for acquiring, at the normal time, a proficiency in reading and writing corresponding to average performance; the deficiency is dependent upon constitutional factors (heredity), is often accompanied by difficulties with other symbols (numbers, musical notation, etc.), it exists in the absence of intellectual defect or of defects of the sense organs which might retard the normal accomplishment of these skills, and in the absence of past or present appreciable inhibitory influences in the internal and external environments.

Eisenberg (1966) states:

> Operationally, specific reading disability may be defined as the failure to learn to read with normal proficiency despite conventional instruction, a culturally adequate home, proper motivation, intact senses, normal intelligence, and freedom from gross neurological defects.

These definitions may be compared with the formulation of the U.S. Office of Education National Advisory Committee on Handicapped Children (1968, p. 14) which spells out the delimiters but without reference to the constitutional factors:

> Children with special [specific] learning disabilities exhibit a disorder in one or more of the basic psychological processes involved in understanding or in using spoken or written languages. These may be manifested in

> disorders of listening, thinking, talking, reading, writing, spelling, or arithmetic. They include conditions which have been referred to as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, developmental aphasia, etc. They do not include learning problems which are due primarily to visual, hearing or motor handicaps, to mental retardation, emotional disturbance or to environmental disadvantage.

It should be noted that this definition is used in the U.S. Congress Bill entitled "The Learning Disabilities Act of 1969."

In the various definitions "specific" or what Applebee (1971) refers to as "residual disorder" is used in the sense of an "idiopathic condition" meaning one with unknown causation according to Eisenberg (1962, p. 4). The more optimistic explanation would be causes not well known as evidenced by the number of studies since the end of the last century. On the positive side "specific" reflects an asymmetry of talents (Doehring, 1968, p. 130) as many children with the disability sometimes show pockets of strengths in areas rather than language functioning. The term "specific reading disability" thus pinpoints the small group of children with severe reading difficulties within the language continuum and is used in the present investigation. The same dyslexic-rich children will also be referred to as disabled readers, children with severe reading disability or dysfunction, or at times dyslexics as a shorthand name.

As in a cognate field of exceptionality, mental retardation, far too much time and energy have been expended on terminologies. A child with severe reading dysfunction, like a pretty girl, is highly visible. We all recognize one when we see one. Or do we? The NINDS Monograph No. 3 (Clements, 1966) has summarized prevailing symptomatologies in identification. These include: variable patterns of test performance;

impairments of perception and concept-formation; specific neurologic indications; speech and communication disorders; motor function disorders; disorders of thinking processes; social and somaesthetic characteristics. The symptoms provide a useful framework for clinicians to evaluate individual children. What then is in a name? While it is useful to delineate terms, it is far more important to proceed "from label to action." In the past decade, knowledge about these children has accumulated and appropriate action has often resulted.

2.4 Heterogeneity of Disabled Readers

The question is sometimes raised as to whether children with specific reading disability form part of the continuum of proficiency in reading or whether they differ qualitatively from those merely backward in reading. If reading is regarded as a unitary entity, there might be some justification in suggesting that reading achievement ranges from very high to very low and that disabled readers are those at the tail-end of the continuum. But reading processes are far too complex to warrant this assertion for all children with reading difficulties. If an analogy may be made with epidemiological studies of the moderately mentally retarded, severely disabled readers too can be thought of as forming a sub-group as illustrated in the small hump to the left of the distribution curve in Figure 2-2. Critchley (1970) accepts this sub-group distribution for children with developmental dyslexia while others have maintained that "specific reading retardation" is merely the lower end of a continuum (Department of Education and Science [UK], 1972). Clinical studies by psychologists and neurologists and the more definitive results from the recent Isle of Wight survey (Rutter, Tizard, and Whitmore, 1970) tend to favour the view that specific reading disability (or reading retardation in the British terminology) is sufficiently distinct from general reading backwardness. Rutter and Yule (1973) base their suggestion on findings of differential sex distribution, of neurological correlates and association with speech and language disorders. From preliminary results of a five-year follow-up of disabled readers, Yule (1973) shows the generally poor prognosis for any reading disability and warns of even poorer prognosis for children with specific reading retardation than merely "backward" ones. Drawing together larger studies of five general population groups varying in age and in geographical areas of England, Yule et al (1974) very recently re-affirm the qualitative difference between "retarded" readers and the mainly "backward" ones in reading.

In the literature it is well documented that there is a preponderance of dyslexic boys over girls. A ratio of 4 or 5 boys to 1 girl is generally suggested (Hallgren, 1960; Orton, 1943; Vernon, 1971). Noting variations from sample to sample, Money (1962, p. 31) is more conservative: "the male incidence is twice that of the female, if not more." The differential development of the two sexes is a vexed problem and the process is often ill-understood. However, some observations from the physical and verbal areas are relevant. Boys have been shown to be slower than girls in physical development from before birth to adulthood with a difference of some two weeks at 20 weeks after conception and roughly 18 months at adolescence (Tanner, 1960). Tanner, Prader, Habich, and Perguson-Smith (1959) further attribute the much slower maturation of boys as due to genes located on the y chromosomes. The slower physical development amongst boys might be a correlate of delays in brain development (Lenneberg, 1967). In the general context of sex differences in verbal ability the classic McCarthy study (1954) noted small differences but these were not significant even on large samples. It was just that when there was a difference it favoured girls and the many studies taken together added up to a significant trend. The same tendency was found by Maccoby (1966) who suggests that the small differences "lie exclusively in productive language, not receptive language, and the girls' advantage is short-lived." (Maccoby and Jacklin, 1973, p.40). While the relatively slow language development in the early years of boys is noted by Terman and Tyler (1954) and the varying interests in the two sexes by McCarthy (1953), Maccoby (1966, Maccoby and Jacklin, 1973) points out that at about age 3 the boys catch up with the girls and in most population groups the two sexes perform very similarly until adolescence, except with disadvantaged children.

The sex difference in reading disability has been variously explained. de Hirsch, Jansky, and Langford (1966) offer as one reason the greater physical immaturity of boys with the implication of slower lateralization of language. Hermann (1959) and Critchley (1970) have advanced as evidence a hereditary disposition. Levy-Agresti and Sperry (1968) suggest differential hemispheric specialization amongst boys and girls, but shed little light on the exact nature of the relationships between this and the different patterns of abilities that boys and girls develop. Each of these assertions finds some support in the literature and the cluster of possible causes are best subsumed under functional cerebral development to be discussed. Whatever the causal factors, the differential sex distribution in specific reading disability bears directly on sampling of children in studies and indirectly on generalizability therefrom.

Apart from differential sex distribution, Johnson and Myklebust (1967) have distinguished between the visual dyslexic and the auditory dyslexic. The visual dyslexic's difficulties are typified by disturbances in learning via the visual modality while the auditory dyslexic finds difficulty in analyzing words into constituent sounds. This distinction is not unlike the visiles and audiles suggested by Wepman (1962, 1968). The distinction also reminds one of Money's (1962) assertion that a dyslexic is perhaps "a person weak in visual imagery and visual memory of all types, the opposite of the person with eidectic imagery and photographic memory." From his work with 107 dyslexics selected from some 350 school referrals, Boder (1971) suggests three sub-groups for more effective remediation: the dysphonetic dyslexic or the visile show primary deficit in the auditory channel and are unable to analyse words phonetically. This group corresponds to Myklebust's auditory dyslexic. The dyseidetic dyslexic or the audile show primary defects in the visual channel and they correspond to the visual dyslexic of Myklebust. The dysphonetic-dyseidetic dyslexic have the combined deficits of the above two groups. Boder notes there is a marked preponderance of dysphonetic dyslexic children in his sample. While the audile-visile distinction is useful, many disabled readers often exhibit difficulties in both the auditory and visual modalities even though one deficit may predominate. The distinction is thus not clear-cut. Rather than drawing this dichotomy, it is more positive to emphasize the transducing of information between the modalities.

The heterogeneity of the reading disabled groups is well brought out by Money (1962, p. 16) in an analogy with psychological medicine:

> It is not at all rare in psychological medicine, nor in other branches of medicine, that a disease should have no unique identifying sign, that uniqueness being in the pattern of signs that appear in contiguity. Out of context, each sign might also be encountered in other diseases, or, in different intensities, in the healthy.

This is succinctly re-stated by McLeod (1969, p. 3):

> Among backward readers, then, is a 'group,' the members of which do not at all exhibit exactly the same symptoms, while the symptoms which they exhibit and which help to identify them as members of that group are symptoms which could also occur because of other disabilities, or, indeed, in normal children.

The heterogeneity within a broadly homogeneous group is one of the reasons why some researchers emphasize case studies. Vernon (1957), for example, has observed that "a great many of the studies of reading backwardness have been made of large, heterogeneous, and ill-defined groups of children." (p. 6). She believes that the only really satisfactory method of investigating reading disability is the detailed study of individual cases. It is clear that by themselves case studies can be as restrictive as the purely survey-type inquiries, though both can yield useful information in different ways. What is needed is a combination of well-defined, large-scale surveys of groups followed by careful studies of individuals. The former approach is exemplified in the monumental surveys undertaken some forty years ago by Burt (1925, 1937) and the more recent Isle of Wight epidemiological study (initiated in 1964) of "educational retardation" and the concomitant emotional and physical correlates (Rutter, Tizard, and Whitmore, 1970). The individual studies approach is typified in a work by Koppitz (1971). In this context, the predictive study of reading failure by de Hirsch, Jansky, and Langford (1966) shows that it is not a single straw but an accumulation of straws that breaks the proverbial camel's back. It is the cluster of perceptual, linguistic and cognitive characteristics acting in concert which contributes to reading dysfunction in the elementary grades.

2.5 An Oblique Glance from Ideographic and Syllabic Languages

Of late, there has been heightened interest in the role of the English orthography and its bearing on the problem of reading difficulties. Some oblique evidence is available from cross-national studies. A "transcultural" study of reading disabilities in some 400 Canadianized Chinese simultaneously learning to read and write English and Chinese by Kline and associate (personal communication, 1971; Kline and Lee, 1969, 1972) may be mentioned. The heralded claim of success in teaching reading-disabled children Chinese characters-like representations (Rozin, personal communication, 1972; Rozin, Poritsky, and Sotsky, 1971) suffers from a small sample size (N = 8) and inherent methodological weakness. An often-quoted study by the Japanese child psychiatrist of Kanner fame Makita (1968) on the rarity (0.98 percent) of dyslexia in Japanese amongst Japanese children has generated more than its fair share of interest amongst English-speaking workers. This perhaps more because of the rarity of cross-national comparison. The Makita study can be criticised on a number of counts (Critchley, 1970; Leong, 1972a). First, the methodology of relying on replies by 247 teachers to questionnaires lacks rigour. Second, the lack of experience of Japanese psychiatrists with reading disability as Makita himself suspected, might confound this syndrome with mental retardation (see Critchley, 1961). Third, the "rarity" might be related to the level of diagnostic services available in Japanese, not to mention the cultural factor of "face saving" when there are less reported cases of failures. All these factors point to the need to interpret the low prevalence in reading disability in Japanese with extreme caution. Indeed, Makita himself states that it is "unthinkable" that mal-development or malformation of cerebral gyri and psychosomatic manifestations are less frequent in Japan than in western countries. His conclusion that reading disability is "more of a philological than a neuropsychiatric problem" is therefore surprising. This speculation was rejected by the present writer (Leong, 1972c) in a symposium shared with Makita himself and other international panelists.

At least two lines of argument can be advanced to show the doubtful validity of Makita's assertion. First, if it were carried to its logical conclusion, one would expect reading disability to be negligible in Finnish or Spanish, both of which were ranked by the linguist Bloomfield (1942) as languages with almost perfect sound-symbol correspondence. Conversely, one would deduce that learning to read in Chinese, which is often erroneously ascribed to sheer rote memory (Halle, 1969), would entail great difficulties and contribute to a higher prevalence of reading disability. Neither of these deductions is correct. There is a closer correspondence between different language systems than is usually thought. For example, the present writer (Leong, 1972b, 1973a) has shown elsewhere the parallel between the decoding of phonemic and morphemic components of Chinese characters and Venezky's (1967) system of grapheme-phoneme relationships via morphophonemic and morphographemic levels. Moreover, Venezky's longitudinal computer-assisted study of a corpus of

20,000 English words and their spelling-to-morphophonemic patterns (Venezky, 1967; Weir and Venezky, 1968) has demonstrated that there is more "regularity" or "predictability" in the English orthography. Indeed, Chomsky (1967, 1970, p. 11) repeatedly asserts that "[English] conventional orthography . . . is near optimal for the spoken language. . . ." This means that the English orthography is not a mere phonemic transcription of speech but bears a much more complicated relationship at the deep level to any given acoustic-auditory phenomenon. An example is the word "courage" with the lexical representation of /koræge/ which becomes [k'ʌrəj̆] in isolation and [karē'yj] when followed by -ous. Another example of the importance of *relational units* and *markers* is in such word pairs as "hen*s*" and "hen*ce*." An orthography, be it English or Chinese, thus differs from the one-to-one isomorphic representation found in Morse dots-dashes or holes punched on Hollerith cards. What the beginning reader or the disabled reader has to learn is the elementary correspondences between the underlying segments of his internalized lexicon and the orthographic symbols. With non-disabled readers, the "learning" of rules comes easily and naturally. With disabled readers, the rules, which may be explicit or implicit, have to be taught, demanded and pursued.

Despite criticisms, the Makita study serves to alert our attention, albeit in an oblique way, to the part played by syllabication in early reading. It also brings up the indirect question of whether the Kanji or Chinese character component or the hiragana or syllabary (phonogram) component in the Japanese language is processed centrally in much the same way. Sasanuma and Fujimura (1971) carried out such clinical studies. They administered tachistoscopic recognition tasks of 10 high-frequency nouns in the two language components to two aphasic adult groups of ten patients each, with and without apraxia of speech (disability in the motor aspects of speech production as distinct from cross-modality linguistic impairment) and two non-aphasic right- and left-hemiplegic groups of six patients each. Among other things, the results showed that the aphasic group with apraxia of speech made a significantly greater number of errors in the Kana processing and in Kanji processing in both the visual and motor tasks. Sasanuma and Fujimura were careful to point out the conflicting findings of differential retention of Kanji versus Kana by patients in scattered clinical studies since the 1930's. They suggested that Kana processing and Kanji processing are relatively independent of each other as identification of the Kana transcription relates to the "phonological processor" in the brain whereas the Kanji transcription bypasses such processing. That the transcriptions can be processed in different "processors" is further supported in a recent replication with 50 aphasics and 30 non-aphasics by the same workers (Sasanuma and Fujimura, 1972). These works thus lend even greater credence to Luria's claim (1966a, p. 411) that "the different bases for writing in different languages must entail a different cortical organisation." The differential processing of spatial-temporal stimuli is seen in a clearer context in subsequent discussions of cerebral substrates of the beginning reading process and simultaneous-successive information-processing. The clinical findings reported here are of more than academic interest and have implications for remediation to be taken up later.

2.6 Parameters of Present Investigation

In order to see the woods for the trees in what can be a tangled jungle of facts (infested with fiction) on reading dysfunction, the researcher must tread a careful path. He should avoid what the economist Galbraith once admonished as the data-rich and theory-poor approach and should maintain a balance between his conceptual framework and empirical quest. Only thus can he see the central issue steadily and see it whole.

2.6.1 Current State of the Art

From time to time doubts are raised about the efficacy of research of its application (Diack, 1965, p. 179; Mathews, 1966). In her comprehensive study of the literature up to 1965 Chall (1967) pointed out that reading research has been characterised by ill-defined terms and goals, by the Hawthorne or halo effects on problems, by conflicting interpretation of data and by unwarranted conclusions. Her stricture is not altogether unjustified. However, all is not rotten in the state of the Art. Within the last decade or so there have been important investigations of models and processes of reading involving the cognate disciplines of psychology, education, linguistics and neurology. No doubt, the leadership of such organizations as the International Reading Association (IRA) and the National Institute of Child Health and Human Development (NICHD) plays a part. Some of the more notable interdisciplinary publications, which also form the back-drop of the present investigation, include: Project Literacy Reports by the Cornell group (Levin, 1964-1967); Theoretical Models and Processes of Reading (Singer and Ruddell, 1970);

Basic Studies on Reading (Levin and Williams, 1970); and the comprehensive The Literature of Research in Reading with Emphasis on Models (Davis, 1971). In particular, these authoritative works on communication by language bringing together the diverse but related fields of psychology and neurology are most valuable: Communication by Language: the Reading Process (Kavanagh, 1968); the more distant Early Experiences and Visual Information Processing in Perceptual and Reading Disorders (Young and Lindsley, 1970); and the recent authoritative Language by Ear and by Eye: the Relationships between Speech and Reading (Kavanagh and Mattingly, 1972).

In the field of learning disabilities in children, the three-phased reports of the National Institute of Neurological Diseases and Stroke (NINDS) have drawn on knowledge from the health sciences and social sciences to summarize facts and to point out crucial gaps in our understanding to the late 1960's. The first NINDS report, Monograph No.3 Minimal Brain Dysfunction in Children (Clements, 1966), which has been referred to, documents terminology and identification. The second report with the same main title (Clements, 1969) deals with the educational, medical and health related aspects. The third report Central Processing Dysfunction in Children (Chalfant and Scheffelin, 1969), two years in the making and based on the review of some 5,000 references, examines critically central processing tasks in learning in children and attempts to identify the anatomical, neurological and physiological components of central processing mechanism in relation to issues in education. The monograph further points to directions for future research needs in the analysis and synthesis of sensory information via the auditory, visual and haptic channels and in dysfunctions in symbolic operations. Also drawing on resources on reading disorders from various disciplines are the scholarly volumes on The Progress in Learning Disabilities edited by Myklebust (1968, 1971).

There are other worthwhile interdisciplinary investigations. Space necessarily limits a brief discussion to three recent inquiries each of which has some import on the present investigation. The three studies are mentioned on disabled readers for their considerable labour and some convergence of psychological and neurological aspects. One is an investigation conducted by Naidoo (1972) for the Word Blind Centre for Dyslexic Children in England between January, 1967 and March, 1969 with 98 Dyslexic boys divided into 56 "reading retardates" and 42 "spelling retardates" each matched with separate control groups. Each child was administered these psychological tests: the WISC, reading and spelling, auditory discrimination, articulation, sound blending, right/left discrimination, motor proficiency, visual retention, finger localization. Information on medical, developmental and neurological aspects as well as parental interest was also collected. Despite the considerable amount of work, the study is flawed on at least two counts. The separation of disabled readers into reading and spelling retardates is necessarily artificial in view of the overlap of patterns of dysfunction. This the author frankly acknowledges towards the end of the study (Naidoo, 1972, p. 115). A more serious shortcoming is the lack of equivalence between the experimental and control groups in measured intelligence where statistically significant differences were found at the 1 percent and 0.1 percent levels for the two groups on the WISC (Performance, Verbal and Full IQ's for the experimental group were 107.9, 105.2 and 107.1 and for the control group were 115.2, 121.0 and 120.0 respectively).

However, the use of cluster analysis, with all its methodological problem of yielding groups because of random variation, deserves attention. Here structure in the taxonomic sense as in biological classification of species is considered across individuals in contrast to the usual structure analysis across variables. A similar caveat of lack of IQ correspondences might be entered against the otherwise interesting 1965-1969 Palo Alto study conducted by Owen and associates (Owen, Adams, Forest, Stolz, & Fisher, 1971) on 76 quartets of children and their parents with a view to "classify . . . the causes and familial patterns of learning disabilities." This aim of delineating more precisely the specificity of reading disability is much better achieved in a more elegant study by Doehring (1968). He examined the pattern of impairment in a group of 39 dyslexic boys aged 10 to 14 compared with two control groups of 39 boys and 39 girls respectively on a total of 109 measures of sensory, motor, perceptual and verbal abilities together with a neurological examination. The comprehensiveness of the test battery is both a strength and a weakness. A strength as the many tests with a "catch-all" intent delineate more clearly patterns of impairment. A weakness because of the undue preponderance of tasks to the sample size. The same can be said of the use of sophisticated multivariate techniques of discriminant function analysis, stepwise regression and factor analysis. They suffer from the same surfeit of over-analysis for the number of children sampled. The various analyses, however, draw attention to the complexities of clusters of abilities underlying reading dysfunction and can be attempted without much difficulty as computer programmes are now readily available. What is more significant is Doehring's finding that disabled readers show patterns of impairment in "non-reading" skills, particularly in certain types of verbal tasks and visual tasks (constrained by the nature of the battery), and that these tasks required "sequential processing." As will be seen in subsequent sections, the present inquiry begins more or less where Doehring leaves off and attempts to delineate more precisely the issue of serial order in both temporal and spatial tasks.

As the reading attainment of most children with specific reading disability is at the initial or decoding stage, the nature of skills required will be clarified.

2.6.2 Cognitive Basis of the Beginning Reading Process

At the risk of over-simplifying, it can be said that the beginning or decoding stage of reading requires the child to discover the correlation between printed units and oral counterparts. Gibson (1969) and Carroll (1970) succinctly outline some of the salient component skills in beginning reading. These include on the part of the child: knowledge of the language; recognition and discrimination of letters of the alphabet; left-to-right principles of the English orthography; dissecting spoken words into component sounds; mapping of correspondence between clusters of letters and sounds and learning to read in "higher-order units." It is in one or more of these skills and the sequencing of these skills that the disabled reader falls down. Thus reading from the early stage on is a cognitive process and no S-R association theory can sufficiently account for the complex condition.

Evidence for the cognitive basis of beginning reading comes from a number of sources: from structural linguist as Bloomfield (1942, 1955), Fries (1962); from psycholinguistic empiricist as Venezky (1967, 1970);

from cognitive psychologist as Eleanor Gibson (1966, 1970a, 1970b, 1972) and her Cornell associates; from the Haskins Laboratories experimental psychologists investigating the relationship between reading and speech perception (Cooper, 1972; Liberman, 1971; Mattingly, 1972; Shankweiler and Liberman, 1972). There is, however, some divergence as to the higher order units that the child should cognize. Is this a phrase, a word, a phoneme or a syllable? Both Bloomfield (1942, 1955) and Fries (1962) subscribe to the primacy of the spoken language over the written one. Fries (1962, p. 119) emphasizes the contrastive spelling and sound patterns in reading:

> 'One can read', insofar as he 'can respond' to the language signals represented by patterns of graphic shapes as fully as he has already learned to respond to the same language signals of his code represented by patterns of auditory shapes.

Fries further suggests a language continuum from the transfer or beginning stage using auditory signs to visual signs through the productive stage where responses to graphic shapes have become automatic to the imaginative stage where the reader can use reading to acquire and assimilate new experience. Where Bloomfield and Fries do not make a distinction is the part played by phonemes in languages spoken and read which differs in complexity one from the other. Venezky (1967, 1970) has made clear the need to distinguish between spelling-sound patterns based on orthography and those based on phonological habits, and has emphasized the predictability of morphophonemic units or units intermediate between the phoneme and the morpheme. For example, the contrasts in the p's in the aspirated "pin" [pʿIN] and unaspirated "spin" [spIn] are predictable as the phoneme /p/ in a word must be pronounced [pʿ] in an initial position as in "pin" and as [p] if it follows /s/ as in "spin." Similarly, the voicing difference between [s] and [z] in the final [s] sound of "cats" and "dogs" is predictable as [s] follows [t] and [z] follows [g]. The native speaker will note the predictability in these examples and seems to need little teaching. However, the [s] and [z] difference between "sip" and "zip" must be formalized and children probably need to be taught the generalization. Drawing on her theory-based work on perception and reading, Gibson (1966, 1970a, 1970b) distinguishes between three phases of reading:

> . . . learning to differentiate graphic symbols; learning to decode letters to sounds ("map" the letters into sounds); and using progressively high-order units of structure.
>
> (Gibson, 1970a, p. 317)

In her earlier work (Gibson, Osser, and Pick, 1963; Gibson, Pick, Osser, and Hammond, 1962), she pointed out the importance of pronounceable letter strings such as "GLURCK" contrasted with "CKURGL" and invariant spelling-to-sound patterns. She later concedes that the term "pronounceable" was perhaps misleading (Gibson, 1969, p. 440) as spelling rules can function independently of pronunciation (Gibson, Shurcliff, and Yonas, 1970) and that detection of structure in orthography is a kind of perceptual learning involving detection of features and feature analysis. She further stresses the benefit derivable from rules with speech and the need to relate reading to the purpose for which it is used (Gibson, 1972). Just as feature analysis applies to visual perceptual learning, so does the process of analysis-by-synthesis in speech perception. Researchers at the Haskins Laboratories have done much to demonstrate that speech perception cannot be equated with a succession of acoustic invariants and is just as complex as reading, if not more so (Cooper, 1972; Mattingly, 1972). Liberman

(1970) shows a schematic spectrogram of the essential pattern of the word "bag." Figure 2-3 illustrates the temporal overlapping of initial and final consonants and the all pervasive influence of the vowel. There is no place to dissect the syllable "bag" into the usual portions (as taught in schools) of [b], [ae] and [g]. The continuous restructuring of the message achieves some parsimony and speeds up communication. This knowledge of syllable segmentation has implications for learning to read and remediation for disabled readers, which will be discussed in subsequent sections, particularly Section 10.2. The temporal telescoping of the phonetic string into syllables can be extended into a comparable collapsing of the deep structures into surface structures as illustrated in Figure 2-4. A processing model for the production of spoken language is presented by Cooper (1972) (see Figure 2-5).

As the illustrations show the primarily linear nature of speech also requires parallel transmission and this is true of the word and sentence levels. This demonstration from psycho-acoustics brings new perspective to speech perception and to the relation between what is thought to be successive and simultaneous.

The necessarily over-simplified resume of the cognitive basis of learning to read as gleaned from current work of linguists, experimental child psychologists and psycho-acousticians brings to the focus of attention the importance of linguistic awareness in reading. Reading as a language-based skill is no more complex than speech perception which may appear to be easier because of its universality and of the redundancy (in the information sense) involved. An understanding of the role of speech perception and its relationship to the reading process will throw light on consonant-vowel error types such as the so-called reversals and

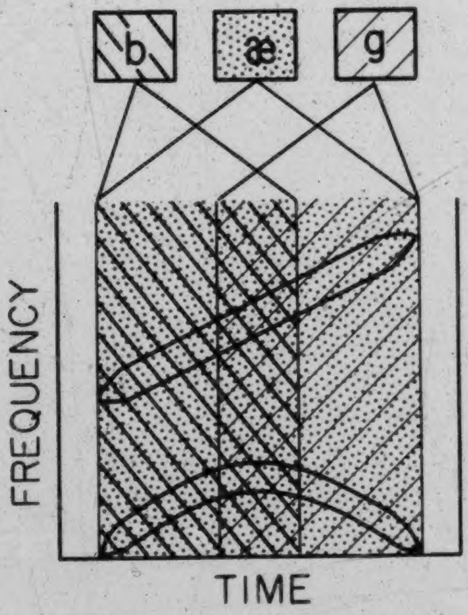
b
æ
g
FREQUENCY
TIME

Figure 2-3. Schematic spectrogram showing parallel transmission of phonetic segments after encoding to the level of sound (after Liberman, 1970).

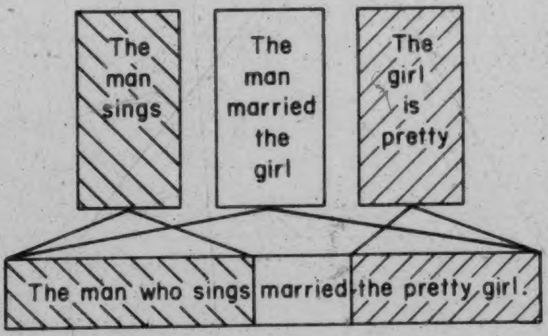
The man sings
The man married the girl
The girl is pretty
The man who sings
married
the pretty girl.

Figure 2-4. Schematic representation showing parallel transmission of deep structure segments after encoding to the level of surface structure (after Liberman, 1970).

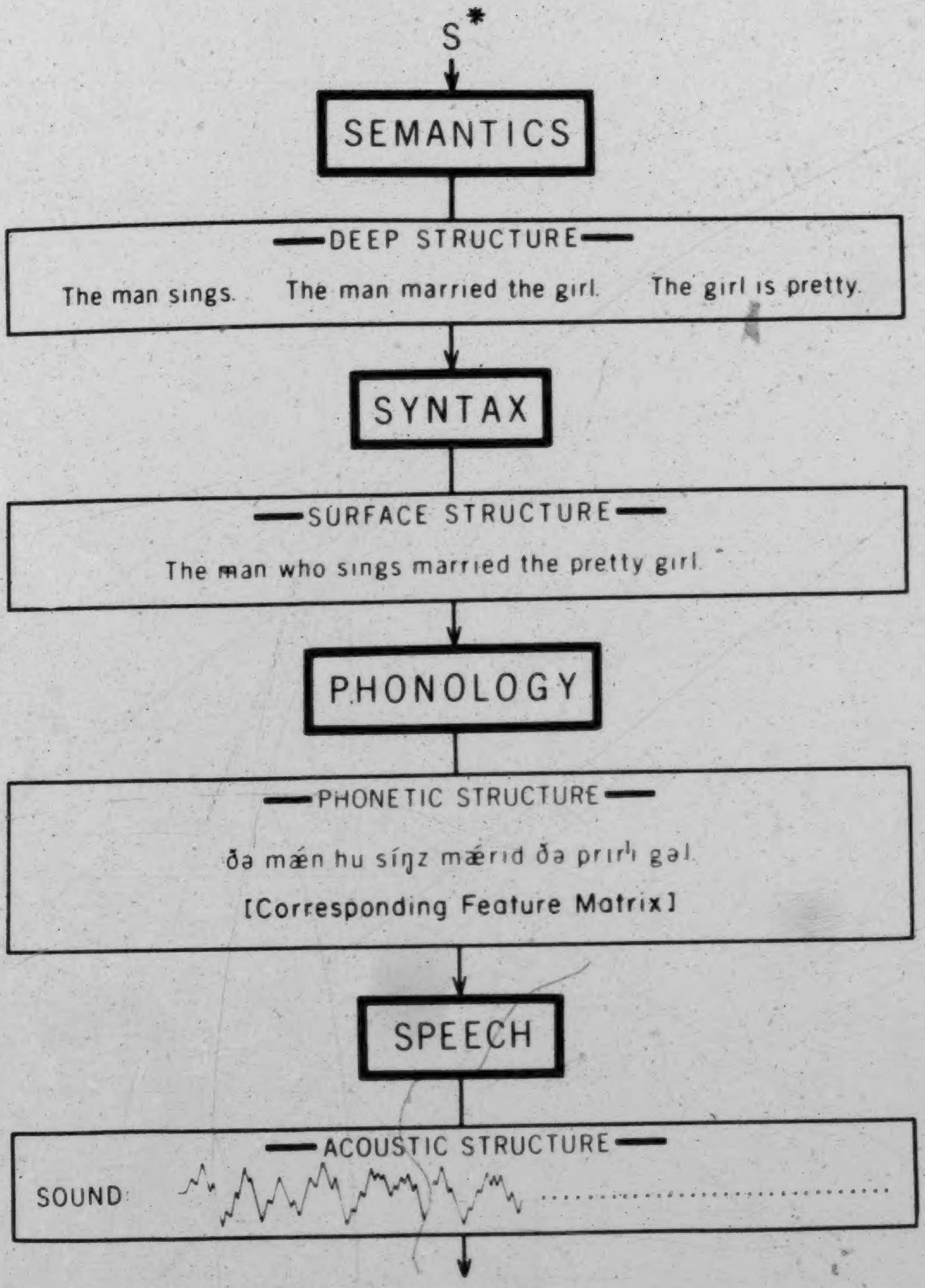
S*
SEMANTICS
DEEP STRUCTURE
The man sings.
The man married the girl.
The girl is pretty.
SYNTAX
SURFACE STRUCTURE
The man who sings married the pretty girl.
PHONOLOGY
PHONETIC STRUCTURE
ðə mǽn hu síŋz mǽrɪd ðə prɪrʰɪ gəl
[Corresponding Feature Matrix]
SPEECH
ACOUSTIC STRUCTURE
SOUND

Figure 2-5. Sequential transmission of spoken language through a succession of processors (after Cooper, 1972).

also has a direct bearing on the dichotic paradigm of the present investigation. These issues will be taken up in subsequent chapters.

2.6.3 Functional Cerebral Development and Information-Processing in Reading Disability

The foregoing on the cognitive basis of reading leads to one of the two major premises of the present inquiry. One is the computer model of information-processing as suggested in the NINDS Monograph Central Processing Dysfunction in Children by Chalfant and Scheffelin (1969) and modified by Senf (1972). According to the model, auditory, visual stimuli (as those mostly concerned with reading) are transmitted to the central processing mechanism (the brain) where they are analyzed, integrated and stored. More than the static computer analogue, feedback is emphasized and the disabled learner is seen as an active participant in the reading process, albeit one with a limited capacity channel and inefficient processing strategies. The information-processing approach provides the framework for spatial-temporal integration so essential to reading and also underpins the original Broadbent (1954) filter theory so basic to the dichotic listening paradigm.

Apart from the short-term memory process it taps, the dichotic listening technique operationalizes functional cerebral development in disabled readers. This second major premise of perceptual differences is seen on the surface as a maturational lag and as such has been espoused, in a different context, by workers as Bender (1958), Gesell (1945), Ilg and Ames (1964) and Schilder (1944). Here it must be said at once that the lag should not be regarded as a mere time-dependent process, least of all as in a nihilistic or negative way. The developmental lag in the present inquiry invokes the concept of hemispheric specialization, in which the differentiation and lateralization of brain function proceeds from the lateralization of gross and fine motor skills followed by the lateralization of sensori-motor functions to the lateralization of speech and language itself. The pattern of deficits may be a combination of: impairment in visual-motor tasks especially figure-copying (Brenner and Gilman, 1966), directional confusion (Critchley, 1964; Orton, 1937), calculation deficits (Belmont and Birch, 1966), spontaneous writing and spelling impairment (Zangwill, 1962), impairment in verbal intelligence (Belmont and Birch, 1966), impairment in inter-modal associations (Birch and Belmont, 1964; Blank and Bridger, 1966). Each of the deficits has received some support in the literature. The developmental framework postulates that the deficits are related to broader disturbance in higher-integrative functions. Younger disabled readers are more disturbed in sensori-motor integration whereas older ones are more delayed in language integration skills. This concept of progressive differentiation is rooted in substantive neuropsychological formulations. Lenneberg (1967) shows that the hemispheric organization of speech evolves from a state of diffuse and bilateral representation in infancy to one of increased lateralization by puberty. Geschwind (1968) has discussed the relationship between brain maturation and ontogenetic development and points out the "terminal" zones (left angular gyri) which have inter-cortical connections necessary for the mediation of more complex language and cross-modal integration skills mylineate the latest. Semmes, Weinstein, Ghent, and Teuber (1960) and Semmes (1968) have suggested that the cerebral lateralization of speech stems from lateralization of less complex motor and somatosensory functions which precede the lateralization of speech. Thus the different perspectives of the biological foundation of language (Lenneberg), its neurological basis (Geschwind) and its neuropsychological substrate (Semmes and associates)--all converge to account for differences in the hemispheric organization of a complex function such as language including reading as a synthesis of elementary sensori-motor functions whose neural organization already favours specialization in the left hemisphere. Maturation thus refers to the process of successive and overlapping changes in growth that take place in the neurological and psychological aspects of the organism and a lag points to a slow or undifferentiated pattern. The physiologic aspect is difficult to evaluate, although there have been some attempts at relating electrophysiological measures to hemispheric specialization of functions (Morrell and Salmy, 1971; Wood, Goff, and Day, 1971). It is, however, possible to generate a number of testable psychological hypotheses which will provide some indirect evidence for the maturational lag concept. Here Bakker in Amsterdam and Satz in Florida have done valuable work (Bakker, 1972; Bakker and Satz, 1970; Satz and Ross, 1973). In particular, Bakker's (personal communication) ongoing research into temporal order perception in dyslexic children have both theoretical and practical implications. The cerebral asymmetry aspect of maturational lag thus has the advantage of explaining reading dysfunction in a developmental context. It is, however, not to the point to ask whether cerebral asymmetry causes reading dysfunction. If causality is ever implied, it is an open question as to the direction and force it takes. There is in fact some evidence that perceptual asymmetry, as tested in dichotic listening, is dependent on certain critical experiences (Bever, 1971). If substantiated, this opens up the possibility of intellectual stimulation for more efficient perceptual strategies at the phonological and syntactical levels of language processing.

These two mainstays of the inquiry--functional cerebral development and information-processing to account for reading dysfunction--will be discussed in greater details in subsequent chapters.

2.6.4 Methodological Problems

In research into reading or reading dysfunction there are some salient methodological problems which should be tackled in order to achieve more meaningful results. These problems pertain to: (a) stages of reading investigated; (b) sampling and (c) research designs and statistical techniques. A brief comment is offered on each.

Attention has been drawn to the need to differentiate stages of reading--the initial or decoding stage and the comprehension stage. Objection may be raised in that all reading is conceived as reading comprehension or reading for meaning. There are, however, different skills involved at the initial stage when children are mastering the mechanisms of decoding letter strings and mapping them to sound and at the subsequent stage when the mechanisms are mastered and reading becomes what Goodman (1968, 1969) calls a "psycholinguistic guessing game." The distinction between beginning reading and fluent reading is well made by Smith (1971) in what he calls "mediated" and "immediate" (in the sense of direct) identification at different linguistic levels. The raw materials of reading, according to Smith, are the distinctive features and linguistic identification conceptualized as a process of categorization. A delimitation of the stage of reading the child is at helps to focus attention on the skills required. From the maturational lag hypothesis, disabled readers chronologically at, say, the grade 3 or 4 level but reading at the grade 1 level show in many ways the cognitive competence of six- or seven-year olds. There is a further corollary relevant to the dichotic experiments in the present inquiry. Recently, Bakker (1973) speculates from his experiments that every stage in the learning-to-read process is characterised by an optimal lateralization pattern and makes the provocative suggestion that "early reading seems to require no dominance; fluent reading necessitates maximum dominance," while intermediate stages seem to profit more from "a certain degree of cerebral dominance" (p. 25). That learning-to-read is related to cerebral development is certain. Whether "little dominance" is required at the initial stage is problematic. The full import will unfold in subsequent chapters with final comments in Section 10.3.

In addition to the need to delimit the stage of the reading process investigated the clear delineation of the nature of the sample studied is also important. In general, two population sources are used, which may be subsumed under the heading of clinical and educational models. In the clinical model, children referred to the clinic for reading disability are studied. It is not unlikely that these children may present concomitant symptoms such as emotional problems and neurological involvement. Rabinovitch (1962), for example, arrived at his classification of "primary" and "secondary" retardation from within a population of children sufficiently disturbed to be in need of residential treatment. In turning from the Scylla of the clinical model to the

Charybdis of the educational model, one runs into other possible biases. In the educational model a group of "poor readers" usually defined as two or more years of reading retardation below grade level is contrasted with a group of "good readers." It is likely that the disabled readers identified will show a skewed distribution in intelligence and this may implicate neurological, psychological and environmental disadvantages. This differentiation of the "clinical" and "educational" models seems to underline the different models of reading difficulty suggested by Wiener and associates (Wiener and Cromer, 1967; Cromer, 1970): (a) a defect, (b) a deficit, (c) a disruption and (d) a difference. This approach is analogous to the defect/difference approach to mental retardation. While the four-fold division is helpful in focusing attention on that which causes reading difficulties rather than letting the blame fall on the child, the zones of demarcation are by no means clear-cut and cognizance should also be taken of neurological substrates. In a generally excellent but not widely known article, Applebee (1971) draws attention to some of the methodological and conceptual problems inherent in research into "reading retardation." A caveat can be entered in that multivariate techniques such as canonical correlation and discriminant function analysis might better describe the inter-relations of several independent patterns of factors in the Applebee sampling. In making the distinction between the "difference" and "defect" approaches to reading difficulty Wiener and Cromer (1967) propose a multiple-antecedent multiple-consequent model which assumes different antecedents will have different consequences, at least theoretically specifiable. One would thus attempt to control as many of the antecedents as possible and relate an antecedent to a specific pattern of difficulty. As an example of this model at work, Wiener and Cromer cite the study of Kinsbourne and Warrington (1963) associating two syndromes of developmental cerebral deficit to different forms of reading difficulty.

Coupled with the problem of sampling is the relevance of statistical designs and of techniques used. The advantage of multivariate methods, where appropriate, has been commented on in connection with Doehring's work (1968). The basic methodological issue involves the choice between the discipline of experimental psychology or correlational psychology or better still integrating the two approaches. Cronbach (1957) explains that "correlational psychology studies only variance among organisms; experimental psychology studies only variance among treatments." He further suggests that:

> Ultimately we should design treatments, not to fit the average person, but to fit groups of students with particular aptitude patterns. Conversely, we should seek out the aptitudes which correspond to (interact with) modifiable aspects of treatment.
>
> (p. 681)

His plea that applied psychologists must deal with treatments and persons simultaneously is not often followed in research into reading or reading disability. Studies need to be undertaken where related factors are identified and as many of the antecedents as possible be controlled in order to pinpoint the effect of a cluster of specific factors leading to a consequent pattern of difficulty.

Proper sampling, correct experimental designs and appropriate statistical techniques alone do not make a good study, given a weak conceptual framework. Granted a viable theoretical construct it is paramount to resolve the above and methodological problems for more interpretable results.

While it is true there is still a gap between research findings and their application, it cannot be denied that we are moving towards a more effective theory of instruction and teaching programmes. The recent editorial of the International Reading Association official journal Reading Research Quarterly (1973-74, 9, 2) sums up the state of the Art well by pointing out that research in reading is all the more needed for "critical thinking" in a field "where we know very little, where the questions are extremely complex, and where there is a long history of developed folklore, biases and issues."

2.7 Review

This chapter has dealt with some psychological aspects of reading difficulties. Survey of the literature shows some 10 percent of the school population are backward in reading. Extending downward from this group is a small subgroup of severely disabled readers variously estimated but probably hovering round 1 percent. These children are the focus of the present investigation. Both extrinsic or cultural-social and intrinsic factors such as mental abilities contributing to reading difficulties are discussed. Prevalent terms and concepts describing this sub-group of children with severe reading dysfunction are commented on. It is suggested the term specific reading disability be preferred over similar ones as developmental dyslexia, reading retardation to denote the condition of the group under study. Within this sub-group there is a great variability as shown in the preponderance of boys over girls, visile-audile dyslexics so much so that complementary studies of children as groups and as individuals are needed. An oblique glance at reading disability in Chinese as an ideographic language and Japanese as a syllabic language provides comparative information on the linguistic basis of reading. Prima facie evidence from the clinical studies of Japanese aphasics demonstrates the differential processing of ideograms and phonograms in different but related "processors" in the brain and has academic and practical implications. From a critical resume of some current interdisciplinary research into the reading process and reading dysfunction, certain research parameters together with attendant methodological guidelines are established. The research need for differential stages of reading, careful sampling of children and relevant statistical designs is stressed. Reading is seen as a cognitive process with the learning of spelling-to-sound invariants as paramount at the initial stage. Reading dysfunction is conceptualized as maturational lag in functional development as shown in speech lateralization and also as inefficient information-processing. The delay or dysfunction in both cerebral and cognitive mechanisms provides a clue to the breakdown of reading proficiency considered as integrated linguistic skills.

CHAPTER 3

A SYSTEM OF CEREBRAL MECHANISMS CENTRAL TO READING AND ITS DIFFICULTIES

> When we are dealing with man or an animal as the receptor we are in a very mixed situation. We are dealing with a receptor of whose general character we may know a good deal, of whose particular hitch-up we know very little. The result is that the sort of thing that becomes a clear-cut quantitative statement in machine communication becomes a qualitative statement in linguistics. . . . Our philologists and engineers both have the problem of studying the properties of a little black box with terminals where they don't know what is inside. This is a much less important problem for the engineer than for the philologist. The engineer, after all, can rip his box open. The philologist can't.
>
> Norbert Wiener. "Speech,
> Language and Thought."
> *The Journal of the Acoustical Society of America*, 1950, 22,
> 696-697.

3.1 The Language Continuum

The primacy of the spoken over the read language (Bloomfield, 1942; Fries, 1962) is validated in clinical studies. Dysfunction in oral communication is often followed by reading difficulties. Chase (1968) has demonstrated in lower animals that there is a critical period for the development of vocal responses. In humans, language acquisition requires extensive integration of many different senses involving the visual, auditory, somaesthetic and kinesthetic modalities. The pattern of disabilities varies in accordance with specific deficits or the functions of one or another of these modalities or of the central association pathways essential for language functioning. Johnson and Myklebust (1967) have emphasized the hierarchy of language acquisition and pinpointed reading as part of the continuum of total language development. This again points to the developmental sequence from the receptive to the expressive language mediated by inner language. In other words, input precedes output as illustrated in Figure 4-1. The child learns to comprehend before he learns to speak and hence to read. A history of late speech development was found by Ingram (1970), Mason (1967), defective articulation by Monroe (1932) and Doehring (1968). Rutter, Tizard and Whitmore (1970) in their Isle of Wight survey found that delay in the onset of speech, articulatory disorders and an immature use of language occurred more frequently among children with "specific reading retardation." Thus preventive and remedial measures at an early age for children who have communication difficulties will do much to alleviate reading difficulties later on.

The relationship between oral competence and reading is also demonstrated in experimental studies. In a careful analysis of oral language of 575 midwestern children from grades 1 to 6, Strickland (1962) shows there is tremendous variety in structures children use and that oral language complexity (sentence length, use of subordination and elaboration) is related to reading competence. Ruddell (1965) demonstrates that the more similar written-language patterns are to the oral-language patterns of the reader, the higher is the reading comprehension of the child and points out the need for a comparative longitudinal study of children's reading success using controlled patterns of language structure based on children's oral language. Drawing on her two long-time endeavours of the development of a theory of perceptual learning and a research programme on reading, Gibson (1969) states that the vital first stage in reading is learning to communicate by spoken language and that "it is not enough to comprehend the meaning of a spoken message; the child must be able to perceive its segmentation and combinatory order" (p. 433). Exactly how the child perceives the components of oral language, how knowledge of spoken language interacts with learning to read and the kinds and amounts of competency needed to develop reading skills are some unresolved questions (Carroll, 1970).

Studies such as those outlined above and the current interest in developmental psycholinguistics prompt one to delve into brain mechanisms involved. Space precludes any lengthy discussion of the nativistic and experimental approaches to the study of psycholinguistics. Briefly stated, the nativists stress the biological foundation of language acquisition. The view of one of the strong proponents (Lenneberg, 1967) on the biological foundation of language may be summarized as follows:

(a) Language is a manifestation of species-specific cognitive propensities. It is the consequence of the biological peculiarities that make human cognition possible.

(b) The cognitive function underlying language consists of an adaptation of a process of categorization and extraction of similarities. This bears some relationship to the critical feature analysis of speech sounds as proposed by Jakobson, Fant, and Halle (1963) and the analysis-by-synthesis model of cognitive information-processing (Neisser, 1967).

(c) "The forms and modes of categorization, the capacity for extracting similarities from physical stimulus configuration or from classes of deeper structural schemata, and the operating characteristics of the data-processing machinery of the brain . . . are powerful factors that determine a peculiar type of form for language."

(d) Maturation brings cognitive processes to a state of language-readiness which is a state of "latent language structure." Maturation of cognitive processes comes about through progressive differentiation and that "the unfolding of language is a process of actualization in which latent structure is transformed into realized structure." To trigger off a reaction, social settings may be required.

(Lenneberg, 1967, pp. 371-379).

Contrasted with the nativistic approach is some experimental work on language acquisition with sub-humans. Gardner and Gardner (1969) succeeded in teaching their chimpanzee Washoe more than 80 different signs in sign language by the time she was four years old and Premack and Premack (1972) taught their chimp Sarah a "vocabulary" of about 130 terms with variously shaped and coloured pieces of plastic. Critics are quick to point out that these successes are the results of careful planning and intensive training as contrasted with the spontaneous learning of languages by the child. Further, the chimpanzees only acquire a limited repertoire of words and lack the flexibility and creativity to communicate grammatical relations as children do. These critics overlook the experimental demonstration of degrees of language competence and the different shades of psychologically strong and weak grammar within this language continuum. McNeill (1970) postulates that the words used by the chimps could be compared to holophrastic speech consisting mainly of inventions of the child, nouns and adjectives. Premack and Schwartz (1966) suggest that the scale of grammar-acquiring devises (GAD) may be applicable to the language systems of mentally retarded children below a certain threshold, say, IQ of 50. In that context, the present writer (Leong, 1974b) has proposed a rapprochement between the developmental psycholinguistic approach as a framework and operant conditioning as a technique in developing language behaviour of moderately mentally retarded children. They, not unlike the chimps in some way, have to be deliberately taught language. In the broader context, Hebb, Lambert, and Tucker (1971) suggest that competence is the result of early cognitive learning. Language acquisition is a combination of sensory-sensory and perceptual learning, both visual and auditory. Imitation, the overt motor speech, is seen as depending on prior perceptual learning and hence the child can imitate only what is already within his competence. Learning is related to the modification of transmission in the Central Nervous System (CNS) where changes take place in the transmission route or cross-connection between such routes. A sensory stimulation may initiate a complex central activity, producing changes in the cortical transmission paths. This view of the importance of experience, though criticized by Pribram (1971a, 1971b) in his logico-practical treatment of holograms, provides some perspective to the structural and functional cerebral systems subserving language skills.

3.2 Brain Mechanisms--Geschwind's Structural View

Geschwind (1964, 1965) suggests that man's brain is structurally unique for the acquisition of language. He states:

> The ability to acquire speech has as a prerequisite the ability to form cross-modal associations. It is only in man that associations between two non-limbic stimuli are readily formed and it is this ability which underlies the learning of names of objects.
>
> (Geschwind, 1965, p. 275).

He explains the structural difference thus. As organisms move up the phylogenetic scale the primordial limbic and non-limbic centres for sensations of vision, audition, and somaesthesis and motor cortex are increasingly separated by new areas of cortex. This separating cortex reaches its greatest extent in man where it occupies most of the surface of the cerebral hemispheres. This association cortex myelinates later in the life of man than do other areas of the brain. Moreover, structurally the different parts of the association cortex are more like each other than are the primordial zones, and there are no significant direct inter-connections between the limbic regions, the motor cortex, and the auditory, visual and somaesthetic cortexes. Each primordial zone has a significant number of connections only to the immediately adjacent cortex. The association cortex itself, however, may have long connections to other regions and there are connections of non-limbic sensory modalities. For example, there is a connection from the primary visual cortex to the immediate adjacent association cortex which has these connections: one to the visual association cortex of the opposite side via the corpus callosum, one to the association cortex anterior to the classical motor cortex and one to the outer and inferior surface of the temporal lobe, which is the association cortex for the limbic structure.

Geschwind (1964, 1965) argues that the essence of language consists in the ability to learn to associate stimuli to two non-limbic sensory modalities. While this ability may exist in lower animals the evidence for this is weak. A monkey can choose between stimuli, but the stimuli chosen are those with limbic connections or consequences, i.e., he learns the stimuli which lead to the satiation of elementary needs such as hunger and thirst, which have their representations in the limbic system. Further, in lower animals there are no direct connections between the association cortexes for the visual, auditory and somaesthetic systems.

In man, the angular gyrus region lying between the association areas of the visual and auditory systems mediate between the sensory modalities and make language possible by permitting the formation of associations between non-limbic sensory modalities.

More recently, Geschwind (Geschwind, 1970, 1972; Geschwind and Levitsky, 1968) has also advanced evidence of marked anatomical asymmetries between the upper surface of the human right and left temporal lobes. The planum temporale (the area behind Heschl's gyrus) is larger on the left in 65 percent of brains; on the right it is larger in only 11 percent. The left planum is on the average one-third longer than the right planum. This area is part of Wernicke's area and makes up part of the temporal speech cortex, whose importance is well established on the basis of both anatomical findings in aphasic and cortical stimulation at operation. A schematic representation of the structural asymmetries of the brain is shown in Figure 3-1. Geschwind further quotes Wada of Vancouver who in a paper at the 1969 International Congress of Neurology in New York confirmed that the right-left asymmetries reported by Geschwind are also present in infant brains with similar statistical distribution. Thus the structural asymmetries are inborn rather than acquired as the result of experience.

The "connection syndrome" and the structural asymmetries of the hemispheres as proposed by Geschwind provide powerful explanation of man's capacity for language. There are, however, several questions which might be raised. One is that object naming does not seem to be simply a product of cross-modal associations but, rather, the product of a further ability to organise several types of incoming information under a supra-heading. It is equally likely that the ability to form cross-

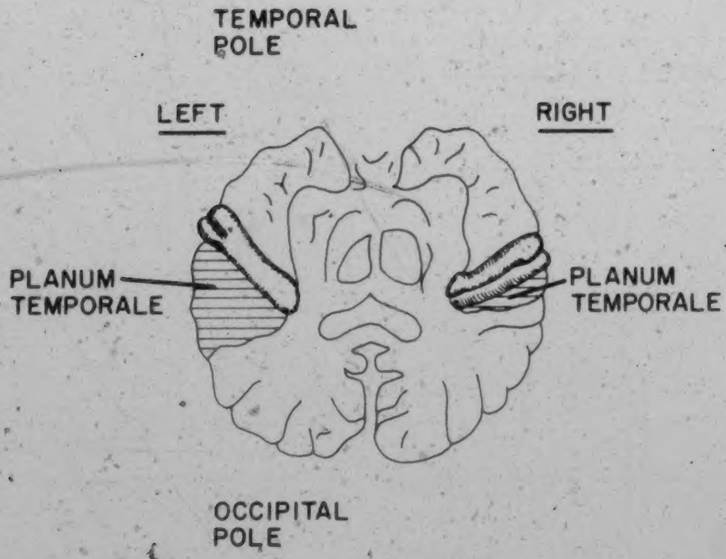
TEMPORAL
POLE
LEFT
RIGHT
PLANUM
TEMPORALE
PLANUM
TEMPORALE
OCCIPITAL
POLE

Figure 3-1. Sketch of horizontal section through the human brain. The planum temporale (shaded) lies behind Heschl's Gyrus containing the primary auditory cortex. Note the larger size of the planum on the left. (From Geschwind, 1972, with permission.)

modal associations is dependent on the ability to use language rather than the other way round, though it is difficult to pinpoint the antecedent-consequent effect.

The above association fibre hypothesis of brain function, and the disconnection hypothesis of dysfunction are viewed with some skepticism by Lenneberg (1967). He maintains that language is not a huge collection of paired associates and points out even aphasic symptoms give little support for a strict associationist hypothesis (p. 217). Pribram (1971b) in advancing the case of holographic transformations as a means for the nervous system to code and recode signals has argued against cortico-cortico connections. Drawing from animal experiments which show the primary functional connections of the cerebral cortex to be subcortical and from human experiments designed to investigate the functions of the cerebral commissure by cutting it, he suggests that associations ought to take place within a system rather than between them. He explains that the brain is constructed to work with images and the incoming stimuli are represented in the brain by wave fronts which through interference effects carry the image and store it by modification of brain protein. While the neural hologram produces spatial encoding (representation), temporal encoding (registration) involves organization and rehearsal and therefore requires attention. Attention to one input involves inhibition of the neural responses to the others, thus segregating neural events. The association areas of the brain act as a "screen" for the neural hologram and an adjuster of the rate of information processing and temporal encoding is a function of the orienting response. Pribram further suggests that the connections tend to separate through suppression of the various parts of cerebral mantal and that cortical dominance is due to a similar inhibitory suppressive mechanism. The compelling anatomical evidence provided by Geschwind on cerebral structural differences and the logical-pragmatic treatment of Pribram on neural hologram only underline the complexity of the central nervous system in explaining man's propensities for language including reading.

3.3 Brain Mechanisms--Luria's Complex Functional Systems

Another approach is to relate man's unique capacity to acquire language in terms of functions of the nervous system rather than in terms of structural differences. Luria (1966a, p. 23) explains that since Pavlov advanced his reflex theories the word "function" has come to mean:

> . . . the product of complex reflex activity comprising: uniting excited and inhibited areas of the nervous systems into a working mosaic, analysing and integrating stimuli reaching the organism, forming a system of temporary connections, and thereby ensuing the equilibrium of the organism with its environment.

The apparatus for the "complex adaptive activity of a whole system" is the upper associative layers of the cerebral cortex, the cortical connections arising in the secondary associate nuclei of the thalamus and the overlapping zones uniting different boundaries of cortical analyzers. Clinical observations of patients with gunshot wounds and brain tumors show that a disturbance of a particular complex function does not in fact arise in association with a narrowly circumscribed lesion of one part of the cortex. A lesion of the same area of the brain at different stages of ontogenesis may lead to completely different consequences. Moreover, the cortical intercentral relationship does not remain the same at different stages of development of a function. Luria (1966b, p. 25) thus rejects the "morphological schemes" of cerebral localization as inadequate to explain higher mental processes:

> . . . since the brain is a highly complex, differentiated entity, possessing a highly specialized system of neurons collected within a particular analyzer, it cannot contain permanent organs confined to a narrow area, responsible for the activity of complex functional systems laid down in the course of life.

Drawing on the work of Pavlov relating the second signal system to higher mental processes and on that of Vygotsky stressing social influence of language on the child, Luria (1965a, 1965b, 1966a, 1966b) further states:

> . . . the higher human mental functions are complex reflex processes, social in origin, mediate in structure, and conscious and voluntary in mode of function.
>
> (Luria, 1966a, p. 32).

Psychic functions are seen as highly differentiated, complex and dynamic systems involving the activity of the entire brain and that speech plays a decisive rôle in the mediation of mental processes. The intercentral systems or functional brain organs arise under the influence of the child's practical activities and are very stable.

In discussing complex functional systems, Luria (1965a, 1966a, 1966b, 1969, 1970a, 1970b, 1973) distinguishes between "three principal functional units" of the brain. These three basic blocks are sketched in Figure 3-2, and their functions are outlined below.

(a) The first block regulates the energy and tone of the cortex. The block includes the upper and lower parts of the brain stem, the reticular formation, the hippocampus. Damage to the first block, namely, the loss of the selectivity of cortical actions and of normal discrimination of stimuli, will bring about marked changes in behaviour such as disturbances in wakefulness, instability of memory traces.

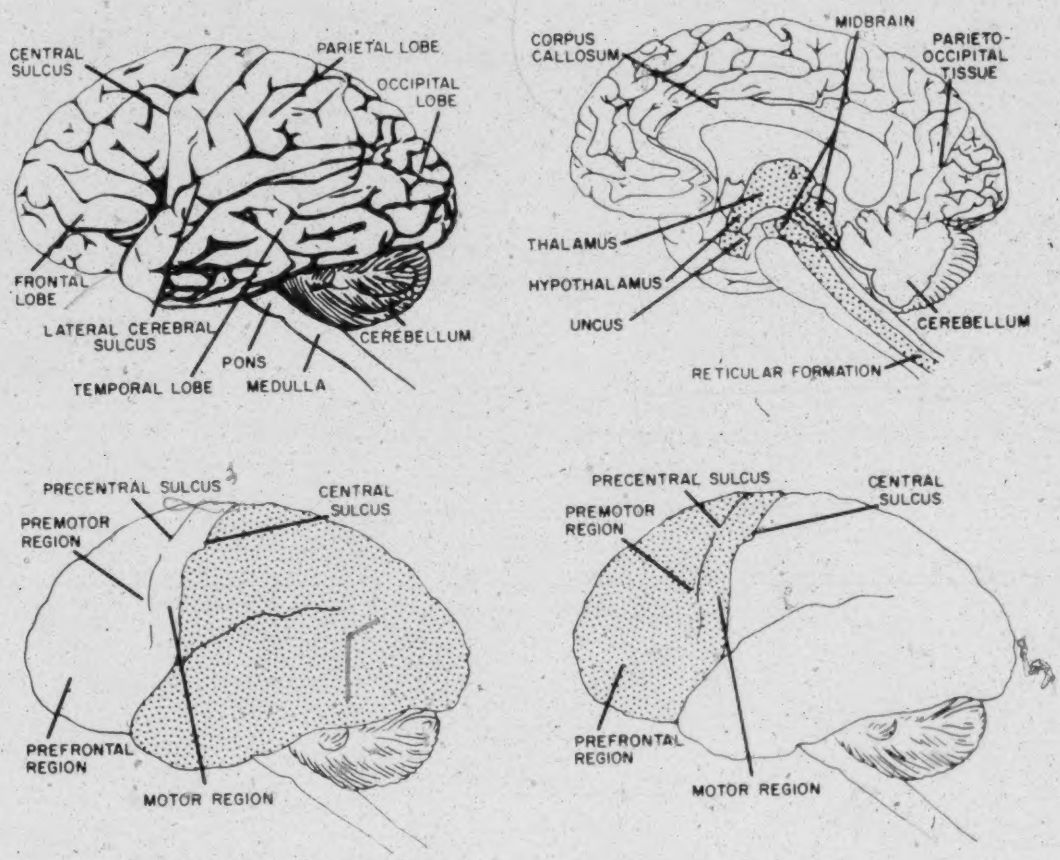
CENTRAL SULCUS
PARIETAL LOBE
OCCIPITAL LOBE
FRONTAL LOBE
LATERAL CEREBRAL SULCUS
PONS
TEMPORAL LOBE
MEDULLA
CEREBELLUM
CORPUS CALLOSUM
MIDBRAIN
PARIETO-OCCIPITAL TISSUE
THALAMUS
HYPOTHALAMUS
UNCUS
CEREBELLUM
RETICULAR FORMATION
PRECENTRAL SULCUS
CENTRAL SULCUS
PREMOTOR REGION
PREFRONTAL REGION
MOTOR REGION
PRECENTRAL SULCUS
CENTRAL SULCUS
PREMOTOR REGION
PREFRONTAL REGION
MOTOR REGION

Figure 3-2. Major blocks of the brain: gross anatomy (upper left); first block (upper right) for regulating energy level of cortex and responding to stimuli; the second block (lower left) for analysis, coding and storage of information; the third block (lower right) for formation of intentions and programs (after Luria, 1970).

(b) The *second block* plays an important part in the analysis, coding and storage of information. Located in the posterior part of the brain, the second block consists of a hierarchical organization of cortical areas: a *primary zone* that sorts and records secondary information; a *secondary zone* that organizes the information further and codes it and a *tertiary zone* where the data from different sources overlap and are combined to lay the groundwork of behaviour. A lesion in a primary zone results in a sensory defect, a lesion in the secondary zone interferes with the analysis of the sensory stimuli, while a lesion in the tertiary zone can cause complex disturbances as visual disorientation in space.

(c) The *third block* comprising the frontal lobe is involved in the formation of intentions and programmes for behaviour. This block controls and regulates human behaviour, particularly the regulation of "the active states started by a verbal instruction."

In Luria's words these blocks can be approximated to "a unit for *regulating tone or waking*, a unit for *obtaining, processing and storing information* arriving from the outside world and a unit for *programming, regulating and verifying mental activity* (Luria, 1973, p. 43, author's italics). It should, however, be borne in mind that any conscious activity is always a complex functional system and takes place through the combined, concerted working of all three brain units.

The necessarily brief discussion of Geschwind's neurological findings of cerebral structural asymmetries and Luria's neuropsychological work on complex functional systems of the brain may raise some questions as to their relevance to the present study. For one thing, the anatomical and neuropsychological theorizing cited from the two noted neurologist and neuropsychologist provides a wider perspective to language functioning and higher mental processes under which reading is subsumed. For another, the works afford some insight into cerebral specialization and place Orton's (1925, 1937) theory of cerebral dominance and strephosymbolia in a more favourable light. Furthermore, Luria's neuropsychological interpretations borne out of some fifty years' clinical observations buttressed by surgical and neurological findings substantiate what Hans-Lukas Teuber calls the "principle of double dissociation of function." And this notwithstanding the latter's objective remark of Luria's "bold generalizations" and "heuristic values" in his preface to Human Brain and Psychological Processes (Luria, 1966b), given recent advances in knowledge of the role of the hippocampus and the "lesser" hemisphere. By "double dissociation" is meant that any local pathological focus in the cerebral cortex will disturb the successful performance of some psychological processes but will leave others intact. Luria (1965a, 1966a, 1966b, 1970b, 1973) documents fascinating clinical cases from his long experience to substantiate and elucidate the double dissociation principle. For example, dysfunction in the parieto-occipital region of the left hemisphere disturbs the spatial organization of perception and movement shown in such activities as map reading, directional sense and also grammatical relationship (e.g., "father's brother" as distinct from "brother's father") but such a focus produces no disturbances of processes involving sequential activities such as speech fluency, or the playing of musical melodies. This principle underlines the Luria-Das paradigm of simultaneous-successive information-processing which will figure still more prominently later. This principle also explains that "*apparently identical psychological processes can be distinguished and apparently different forms of mental activity can be reconciled* (Luria, 1973, p. 41, author's italics). May this not provide a clue to the cerebral mechanisms involving in such higher functions as initial reading and its dysfunction?

3.4 Cerebral Dominance to Cerebral Specialization

Zangwill (1962) distinguishes between two meanings of "dominance." One is the notion that one hemisphere exercises direct control and hence dominates over the other hemisphere in coordinated actions. The other notion implies that the central mechanisms subserving speech, and probably other higher functions, are located predominantly in one hemisphere. It is now known that the two hemispheres are not equipotential and each has its specialized functions. It is therefore more appropriate to speak of cerebral specialization than of dominance.

Knowledge of localization of cerebral functions along the anterior-posterior dimensions of the brain, without regard to hemispheres, dates back to Hippocratic writings ca. 400 B.C. and Luria (1966a) traces the contributions made by various early workers. Of these, Paul Broca and Carl Wernicke in the 19th century may be singled out. Broca in 1861 was the first to point out that damage to a specific portion of the brain results in disturbance of language output. The portion identified, now known as Broca's area, lies in the third frontal gyrus of the cerebral cortex just in front of the cortical region in which lies the motor representation for the organs of speech (see Figure 3-2). Hence the area was attributed by Broca to be more responsible for the rules by which heard language could be coded into articulatory form, although it is now known the coding can be a complex process, and that Broca's aphasia is based, not on a disturbance of the articulatory schemes themselves, but on a disturbance of the serial organization of phonemic articulatory processes (Luria, 1966b). In 1865 Broca reported that damage to specific areas of the left half of the brain led to disorders of spoken language while destruction of the corresponding areas in the right side of the brain left language abilities intact. Joynt (1964) notes the cautious interpretation of Broca in face of the difficulty workers in those days had in conceptualizing and accepting ideas of the contralateral dominance of specific areas rather than the whole hemisphere. Broca later postulated a relationship between handedness and hemispheric cerebral dominance for language.

Carl Wernicke in 1874 established the fact that there are language differences between the aphsias produced by damage in the left temporal lobe and those produced by lesions in the frontal lobe in Broca's area. Wernicke's area lies between Heschl's gyrus which is the primary receiver of auditory stimuli and the angular gyrus, which acts as a way station between the auditory and the visual regions (Figure 3-2). When a word is heard, the output from the primary auditory area of the cortex is received by Wernicke's area. If the word is to be spoken, the pattern is transmitted from Wernicke's area to Broca's area where the auditory form is aroused and passed onto the motor area that controls speech. When a word is read, the output from the primary visual areas passes to the angular gyrus, which in turn arouses the corresponding auditory form in Wernicke's area. Thus when Wernicke's area is damaged, speech is fluent but has little content and comprehension of spoken and written language is usually lost. From his study of patients, Luria (1970b) is in general agreement with the early suggestion of Broca and Wernicke as to the basic pattern of speech localization within the complex functional system. Luria finds that when the gunshot site lay over Wernicke's or Broca's area the result is almost always severe and permanent aphasia.

From these early studies the concept of cerebral dominance is now extended from language functions to other activities. The left hemisphere, for example, is related to "ideomotor apraxia" or inability to perform familiar acts on verbal command or by imitation. Widespread disease of the left hemisphere in man is often associated with a pattern of functional deficits involving left-right confusion, dyscalculia, dysgraphia, finger agnosia, constructional apraxia and interference in verbal intelligence. The first four deficits were often referred to as Gerstmann's syndrome which is usually attributed to a localized lesion in the region of the left angular gyrus. This view is now held to be too restrictive as left-right disorientation may be due to lesions in any part of the parietal and posterior temporal lobes although localization to the left is generally accepted (Benton, 1961). There is also evidence that left-right confusion, finger agnosia, dyscalculia, and dysgraphia do not form a distinct constellation of deficits and that they may correlate as often with other neuropsychological components such as constructional apraxia, dyslexia and depressed verbal intelligence. Nevertheless, a relationship between the Gerstmann symptoms and left hemisphere disease has generally been observed (Benton, 1961; Poeck and Orgass, 1967). From his examination of some 800 patients Luria (1966a) concludes that individual differences in the degree of aphasic disturbance "cannot be entirely explained by the severity of the lesion. . . . The degree of dominance of one hemisphere in relation to lateralized processes such as speech varies considerably from case to case (p. 89)."

3.5 Cerebral Specialization, Handedness and Speech Brainedness

Goodglass and Quadfasel (1954) hold the view that the tendency for language to centre predominantly in the left hemisphere is independent of handedness. Penfield and Roberts (1959) find no true relation between dexterity and speech and suggest jocularly that "brain function and handedness may be unrelated except by disease" (p. 102). Cernacek (1964) points out many traditional tests of laterality give conflicting results; there are lateral preferences for different hand, wrist, elbow, leg, foot and eye functions. Critchley (1964) stresses the need for a battery of tests to determine handedness which may be relative to the assessment instruments used. As will be shown, these earlier views have given way to some current neuropsychological findings which suggest there is some indirect, but strong association between handedness and brainedness particularly with lateralization of speech. The relationship, however, is a complex one.

In general, cerebral dominance is more characteristic of the dextral rather than the sinistral. Hecaen and Piercy (1956) suggest that brain mechanisms serving language are different in left-handed and right-handed people. In the left-hander there is a more nearly equal bilateral representation, and also more diffuseness of language mechanisms within the hemisphere contralateral to the dominant hand. Lesions of the left hemisphere may produce ipsilateral as well as contralateral effects on the hands whereas right-hemisphere lesions are typically followed mainly by contralateral effects (Critchley, 1953). Further evidence for the different cerebral organization of speech in sinistrals and in dextrals is obtained from clinical observations that aphasia following injury of the left hemisphere disappears more rapidly and more completely in sinistrals than in fully right-handed patients (Luria,1970b; Zangwill, 1960). This suggests unilateral specialization is less complete in sinistrals than in dextrals and allows a higher degree of functional restitution after damage to the dominant hemisphere. With his long experience in neuropsychology, Benton (1965) states that ambicerebrality or bicerebrality ("representation" of language in both hemispheres) is rare in the right-hander but not at all rare in the left-hander.

An integrative view of hemispheric specialization for speech and handedness is provided by Semmes and associates (Semmes, 1968; Semmes, Weinstein, Ghent, and Teuber, 1960). They suggest that the cerebral lateralization of speech stems from lateralization of less complex motor and somatosensory functions which precede the lateralization of speech. Sensori-motor laterality precedes sensory laterality, which is followed by lateralization of language. The lateralization process begins with manual tasks which become differentiated between four to six years of age (Hecaen and Ajuriaguerra, 1964) and should stabilize between six and twelve years. Language differentiation which represents the highest level of lateralization in man (Penfield and Roberts, 1959) is achieved between nine and thirteen (Belmont and Birch, 1965; Benton, 1962; Lenneberg, 1967). Semmes (1968) argues forcibly that each of these hierarchical functions are more focally represented within the left cerebral hemisphere and more diffusely organized in the right hemisphere in man. The focal representation of elementary functions in the left hemisphere favours integration of similar units and consequently specialization for behaviours which demand fine sensori-motor control, such as manual skills and speech. Conversely, diffuse representation of elementary functions in the right hemisphere may lead to integration of dissimilar units and hence specialization for behaviours requiring multimodal coordination, such as various spatial abilities. Semmes further argues that focal representation in bringing about a more precise coding of input of stimuli and making possible a more finely modulated control of the output is the basis of hemispheric dominance. Man's capacity for language and symbolic thought is "ultimately based on the phylogenetic trend towards increased localization of function and that the left hemisphere has proceeded farther than the right in this direction . . . it tends to support the early notion that there is a close connection between handedness and speech. . ." (Semmes, 1968, p. 23). The explanation of focal and diffuse representation of each of the hemispheres provides argument for some form of relationship between cerebral function, handedness and speech lateralization. The generally accepted explanation also provides the theoretical underpinning of the maturational lag postulate of Satz and associates (Bakker and Satz, 1970; Satz and Ross, 1973) which in turn is one of the mainstays of the present investigation.

In actual clinical practice, observations of patients with brain pathology who develop aphasia also support the hypothesis of at least a partial relationship between handedness and speech brainedness (Penfield and Roberts, 1959; Zangwill, 1962). Penfield and Roberts summarize a study of a group of individuals who experienced language impairment subsequent to brain operation. Of a total of 157 persons who were right-handed and who had an operation on the left side of the brain, 78 percent developed aphasia. Similarly, of those who were left-handed and who had an operation on the left side of the brain, 72 percent became aphasic. Of those who were operated on in the right hemisphere, only 0.5 percent of those who were right-handed developed aphasia whereas of those who were left-handed, 6 percent developed aphasia. These clinical observations show that the dominant hemisphere for language is most often the left one and that even in left-handers the left hemisphere is still very likely to be dominant for language function. Similar conclusion was reached by Zangwill (1962) who found a high incidence of aphasia (> 95 percent) in right-handers with lesions in the left hemisphere compared with the incidence of aphasia (> 35 percent) in left-handers after right hemisphere lesions.

In recent years, two reliable procedures have been used to study the relationship of cerebral functions and speech lateralization and indirectly handedness. The intercarotid artery sodium amytal test for patients of neurosurgery was first introduced by Wada in 1949 (Wada and Rasmussen, 1960) and the dichotic listening technique based on Broadbent's work (1954) was originally used by Kimura (1961a, 1961b) on patients with brain pathology. The Wada test involves the injection of sodium amytal into the carotid artery of one side of the neck or the other. The sedative disturbs the function of the cerebral hemisphere on that side for a short while and if the patient's speech is disturbed as well one infers that speech is mainly represented in that hemisphere. The results of the Wada test showed that the vast majority of right-handed patients were left brained for speech (90-95 percent) while the proportion of left-brainedness in left-handed patients was significantly smaller (Branch, Milner, and Rasmussen, 1964). Also, about 15 percent of the left-handed patients had bilateral representation of speech. Thus right brainedness is more common among left handers and ambidexters than among right handers, even including cases of early left brain damage. The insightful observations of Benton (1965), Hecaen and Piercy (1956) are validated. Rossi and Rosadini (1967) in their study using the sodium amytal test of 126 hospitalized subjects also cautiously advanced the hypothesis of bilateral representation of speech in left-handed adults.

An important contribution to the perennial and vexed issue of cerebral dominance and handedness is made by Annett (1964, 1967, 1970, 1972) in a series of elegant studies. She points out the need to distinguish between consistent sinistrals and inconsistent ones. When pure left handers are distinguished from mixed handers; right, mixed and left handers occur in binomial proportions in complete samples. These proportions are linked with the hypothesis that handedness depends on a combination of two factors: heterozygotes manifesting mixed hand preference, and homozygotes manifesting consistent hand preference. Annett suggests that dominant homozygotes have left speech representation, recessive homozygotes right hemisphere representation and heterozygotes a capacity for representation in either hemisphere. In most heterozygotes speech is expected to develop in the left because of cultural pressures, but in the event of damage to that hemisphere it is hypothesized that the alternate hemisphere would mediate language. In homozygotes, however, such a transfer of function is not expected to take place so readily.

Very recently, Annett (Annett and Turner, 1974) reaffirms her hypothesis and further explains that human handedness is distributed in two groups: a majority whose handedness is normally distributed and shifted to the right and a minority whose handedness is normally distributed and not shifted to the right. Thus the Annett view of cerebral dominance enhances the interpretation of the fact that some left-handers would have right hemisphere representation and some with left representation. It also explains the more rapid recovery from aphasia in left than right-handers in accord with the observations of Benton (1965), Luria (1970b), Zangwill (1960).

Space limitation does not do full justice to the vexed and much researched area of cerebral dominance, speech brainedness and handedness. Suffice it to say that adequate theoretical and clinical findings have been critically examined to show the complexity of the problem and the difficulties involved in attempting to extrapolate from handedness to reading performance in quantitative terms. A more fruitful way is to investigate the ramifications of speech lateralization related to perceptual asymmetries and as a memorial process underlying reading dysfunction.

3.6 Orton's Theory of Strephosymbolia Revisited

In view of current work in cerebral dominance the much maligned theory of strephosymbolia or twisted symbols proposed by the neuro-psychiatrist Orton (1925, 1929, 1937) to account for dyslexia deserves re-appraisal. Orton pointed to the clue of frequent occurrence of reversal errors in dyslexics and distinguished between: (a) kinetic reversals in which the order of letters in a word or the order of the words in a sentence is reversed and (b) static reversals involving confusion of a simple letter with its mirror image. He explained the pattern of excitation aroused in the cortical hemispheres in visual perception thus:

> The brain contains right and left visual areas which are exactly alike except for their opposite orientation, and we think, therefore, that the existence in the non-dominant hemisphere of engrams of different orientation from those in the dominant hemisphere cannot be lightly dismissed as the probable source of static and kinetic reversals and of the spontaneous ability in mirror reading and mirror writing.
>
> (Orton, 1937, p. 155).

Thus a single form arouses two patterns of excitation (engrams) which are mirror-images and the discrimination of a figure from its mirror-image is achieved through the development of lateral dominance which enables one cortical hemisphere to suppress the engrams of the other. When there is incomplete dominance there is a similarity between the engrams in the two hemispheres and hence reversal occurs.

While the theory of strephosymbolia is viewed with skepticism by some (Vernon, 1971) and condemned as "outdated" by others (Harris, 1968, p. 164), Orton has come to be recognized for his foresight by such eminent neurologists as Masland (1966, 1967, 1968). Pribram's hypothesis (1969) that neural activity takes the form of both spatial and temporal codes--the former for representation and the latter for registration of stimuli--reminds one of the engrams that Orton so presciently wrote more than thirty years ago. In reviewing the laboratory and behavioural observations on the effects of the essential bilaterality of the nervous systems of animals and man on left-right responses and mirror image discrimination among stimuli, Corballis and Beale (1971, p. 100) find support for Orton's view that:

> Memory traces associated with reading and writing may to some degree be laid down in mirror-image form in the cerebral hemisphere opposite the hemisphere that is dominant for speech, and that in some cases the mirror-image representation may intrude to disrupt normal performance.

The recent development of the split-brain technique (Gazzaniga, Bogan, and Sperry, 1965; Sperry, 1961, 1964, 1970) confirms some of the heuristic value of Orton's theory. Sperry studies the discrimination learning of a split-brain monkey by surgically cutting the commissure linking the two hemispheres. He maintains that the corpus callosum has the important function of allowing the two hemispheres to share learning and memory by either transmitting the information at the time the learning takes place or by supplying it on demand later. In the first case the engrams, or memory traces, of what is learned are laid down both in the directly trained hemisphere and, by way of the corpus callosum, in the other hemisphere as well. In the second case a set of engrams is established only in the directly trained half, but this information is available to the other hemisphere, when it is required, by way of the corpus callosum. This latter system of single-engrams is a sign of lateral dominance. Sperry suggests that in man the single-engram system tends to prevail, particularly in all memory relating to language (Sperry, 1970); whereas lower animals such as cats use the double-engram system and monkeys seem to fall somewhere between the two systems, sometimes using one and sometimes the other system. This distinction seems to correspond to the relative extent of lateral dominance in these three species: man with most laterality and cats with the least. Thus far, Orton's theory is substantiated. But the related postulate that the ability to make discriminations on the basis of orientation as a direct function of the extent of lateralization in a species meets with qualified support only. The expectation that cats would perform less well than monkeys and all species less well than man was not maintained. Lashley (1938) found no clear evidence that the rat confuses mirror-image figures while Sutherland (1963) was surprised at the facility with which cats discriminated between differently orientated oblique rectangles. However, octopuses (Sutherland, 1960) seem to have the same sort of problems as man. Orton's view of cerebral dominance thus seems to have come nearly full circle some forty years later.

3.7 Auditory Perception and Cerebral Specialization

Orton's early suggestions of right and left visual excitations have been experimentally tested with tachistoscopic bilateral (simultaneous) or unilateral (successive) presentations of verbal stimuli (digits, words) and "non-verbal" ones (shapes, dots) at exposure durations just below the threshold (150-200 milliseconds) to the left visual half-field (LVF) or the right visual half-field (RVF). In general, in unilateral presentations letters were more accurately identified in the RVF. This is taken to reflect hemispheric asymmetry (Kimura, 1961b, 1966). However, Boller and De Renzi (1967) pointed out that studies of visual memory and hemispheric localization were often confounded by coding strategies. They suggested recognition rather than reproduction responses should be used as the involvement of the motor modality might vitiate results. This brief mention of laterality differences of LVF and RVF is made as a backdrop to auditory perception and cerebral asymmetry in dichotic listening tasks. In some ways studies of visual perception and lateralization seem to parallel those of auditory perception and cerebral dominance, but the results are less unequivocal. In a critical review, White (1969) advances these reasons for the difference: (a) The confounding effect of verbal coding in "non-verbal" visual tasks as mentioned by Boller and De Renzi (1967) earlier; (b) Dichotic listening tasks are defined more as memory than perceptual tasks as characteristic of visual experiments; and functional asymmetry is related more to the "holding" rather than to the processing strategy; (c) In dichotic experiments competing stimuli are presented at a fast rate whereas visual input is usually presented under non-competitive conditions. The explanation is that when stimuli are input to the sensors simultaneously, the stimuli transmitted along contralateral pathways occlude those transmitted along the ipsilateral pathways, but that when information is presented separately the contralateral and ipsilateral pathways function more or less equally (Kimura, 1964).

Very briefly, the dichotic technique based on Broadbent's information processing model (Broadbent, 1954) involves the simultaneous presentation of two different stimuli, one to each ear, and has been used successfully to study humans. In general, left-brained dominant normals show a superiority of the right ear over the left ear in reporting simultaneously presented verbal materials such as digits (Broadbent and Gregory, 1964; Bryden, 1967b;Treisman and Geffen, 1967) while "non-verbal" materials such as musical melodies are more accurately reported in the left ear (Kimura, 1964). This is necessarily an over-simplified account of the right-ear advantage for speech, as researchers in psychoacoustics, such as those at the Haskins Laboratories, have further delineated the nature of hemispheric specialization for speech perception. The conceptual, methodological and practical problems related to dichotic listening experiments will be explored in depth in the relevant sections (Chapter 5 largely). The main point here is to show, as mentioned by Kimura (1964) in the preceding paragraph, that lateral differences between left and right ears in perceiving competing stimuli seem to reflect the greater strength of the crossed auditory pathways and the specialization of the auditory areas of each hemisphere of the brain for processing different classes of stimuli. There is evidence for stronger contralateral than ipsilateral auditory pathways in the cat (Hall and Goldstein, 1968; Rosenzweig, 1951) and human patients with temporal lesions (Bocca, Calearo, Cassinari, and Magliavacca, 1955) and for inhibition of the ipsilateral signal in man during dichotic listening (Milner, Taylor, and Sperry, 1968; Sparks and Geschwind, 1968). Sparks and Geschwind suggest that materials from one ear has two pathways for reaching the ipsilateral temporal lobe. One route is the direct one via the ipsilateral auditory pathway. The other route follows the longer but stronger contralateral pathway to the opposite temporal lobe and then returns via the corpus callosum to the ipsilateral temporal lobe. This explanation is illustrated schematically in Figure 3-3. Sparks and Geschwind maintain that the callosal pathway plays a role in the left ear performance on dichotic listening tasks when the left temporal lobe is dominant as it has been shown that left ear efficiency on dichotic listening declines after right temporal lobectomy. These findings of Milner, Taylor, and Sperry and Sparks and Geschwind confirm the earlier

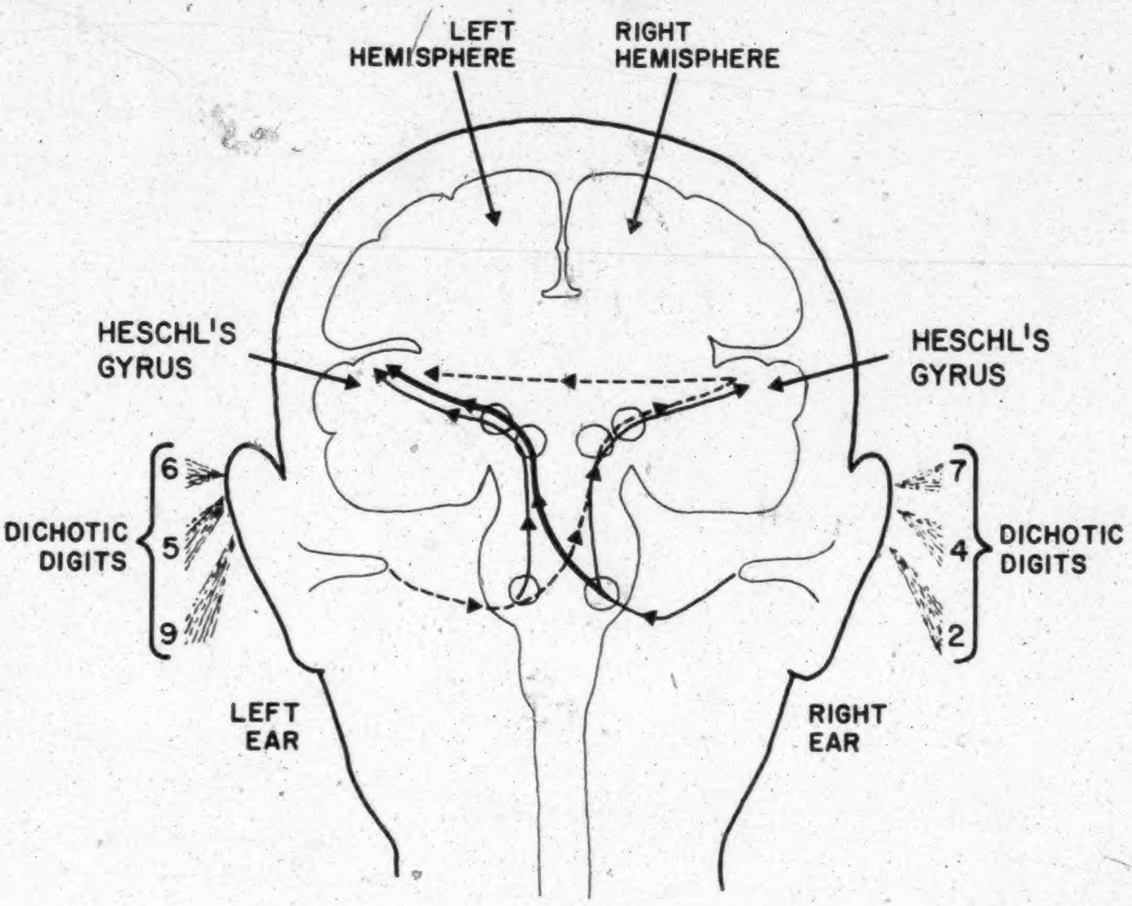
LEFT HEMISPHERE
RIGHT HEMISPHERE
HESCHL'S GYRUS
HESCHL'S GYRUS
6
5
9
DICHOTIC DIGITS
7
4
2
DICHOTIC DIGITS
LEFT EAR
RIGHT EAR

Figure 3-3. Schematic representation of crossed auditory pathways in dichotic listening. The neural connections from one ear to the hemisphere on the opposite side are stronger than the connections to the hemisphere on the same side. The broken line represents the indirect (perhaps more important) route from the left ear to the dominant left temporal lobe. (After Kimura, 1973; Sparks & Geschwind, 1968.)

investigation of Efron (1963a) who found that for two stimuli to be judged as simultaneous, the one directed to the non-dominant hemisphere has to precede the other by 2 to 6 milliseconds. Efron suggests that signals reaching the non-dominant hemisphere have to be relayed to the dominant one and that the integration or matching is carried out there.

3.8 Reciprocal Specialization of the Hemispheres

Studies of visual and auditory perception and hemispheric specialization provide a glimpse of the cerebral substrate of language. This is the dependence on the establishment within the left hemisphere of intersensory associations. Auditory patterns of language are activated within the temporal association area. The meaning of these sounds requires an interaction within the language association area of the angular and supra-marginal gyrus. Word recall may require the excitation of more widely dispersed cell assemblies in this area. The formation of speech requires the initiation of activity within the motor engrams for language in the frontal lobe. Other forms of activities such as writing, reading and arithmetic may be regarded as an extended, albeit more complex, form of language. Geschwind (1964, 1970, 1972) has pointed out that intersensory association is unique in man and Birch and Belmont (1964, 1965) have shown a relative difficulty of intersensory transfer in disabled readers. Further evidence for the role of the dominant angular gyrus region in the mediation of intra- and cross-modal association is provided by Butters and Brody (1968) who found that patients with dominant parietal lobe damage were impaired on auditory-visual, tactual-visual and visual-tactual cross-modal matching tasks. The importance of the left hemisphere for language functioning or as a "trigger mechanism" or "primary initiator of activity" (Masland, 1967) for such activities is amply demonstrated, as there is little or no syntactic capacity in the right hemisphere, which, however, also makes important actual or latent contributions. Whether the left or right hemisphere is dominant is therefore relative. The two hemispheres work in a closely integrated way and complement each other in some kind of reciprocal specialization. Kimura (1973a) speculates that probably the "right hemisphere specialization is more pronounced in males than in females and that such specialization may sometimes be advantageous" and that "it appears that for some intellectual functions the brains of males and females may be differently organized." (p. 78)

Within this matrix of hemispheric specialization, intrahemispheric differences are important. In subhumans these differences are marked, whereas in man they are complicated by the differential functions of the hemispheres. In the temporal lobes bilateral lesion of the hippocampus leads to memory defects. Penfield and Perot (1963) provide evidence of the association between temporal lobes and memory. They have reported various interpretative illusions resulting from electrical stimulation of the temporal lobe in the conscious patient but not from the stimulation elsewhere on the cortical surface. There is some clinical evidence of route-finding difficulties and parietal damage on either side. The frontal lobes are important for intellectual development as other cortical areas. Luria (1965a, 1966b, 1970a, 1970b, 1973) states that frontal lobe lesions primarily disturb behaviours involving serial ordering, lead to the loss of kinetic melody, the loss of dynamics in thinking. The role of the frontal lobes is that of the formation of intentions and programmes for behaviour.

A synthesis of the reciprocal functions of the "major" and "minor" hemispheres is provided some time ago by Benton (1965). He points out the difference between overt behaviour and underlying abilities and that a complex performance (e.g., Koh's Block Designs) has multiple determinants. Within this context, he provides a qualitative and quantitative interpretation of the differential functions of the hemispheres: the usually held view that the left hemisphere mediates language and the right hemisphere "specializes" in perceptual, constructional or motoric functions. Benton's view is consonant with findings from more recent split brain experiments. Robinson and Voneida (1970) showed that the two hemispheres have a complementary relationship in that more complex tasks can only be performed adequately by split-brained cats with the simultaneous participation of both brain halves. While one or the other hemisphere may be significantly more involved in the mediation of a given task, there is no evidence to suggest that this asymmetry is species-specific in lower animals. The double-dissociation experiments which are possible in split-brained adult humans (Sperry, 1968) are not seen in infrahuman species. In man, the "complementary-different" relationship between the hemispheres is necessary, while for infrahumans, a "complementary-same" relationship could be obtained.

3.9 Review

The preceding discussion of cerebral specialization and language has drawn heavily on sources in experimental neurology and neuropsychology. The exposition shows the complex cerebral substrate subserving the language continuum including the initial reading process. Geschwind stresses cross-modal associations facilitated by structural asymmetries of the two hemispheres. Luria discusses complex functional systems and endorses the principle of double dissociations. Both these cerebral mechanisms--structural and complex functional mechanisms--provide a clue to a better understanding of cerebral dominance. So also the theoretical views of focal and diffuse representations in the hemispheres. The genetic view involving dominant and recessive homozygotes and heterozygotes adds some clarity to the often consistent but shadowy relationship between cerebral functions, handedness and speech lateralization. The heuristic value of Orton's theory of hemispheric dominance and strephosymbolia is vindicated, at least in part, in recent split-brain experiments. The role of auditory perception in cerebral specialization is explained by differential strengths of ipsilateral and contralateral neural pathways. It is suggested that the "complementary-different" relationship between the hemispheres in humans is necessary and that the actual or latent contributions of the "lesser" hemispheres should be taken into account.

The relevance of this chapter to the present investigation may be briefly restated. Reading as a complex form of language activity has a psycho-physiological component involving the dynamic mosaic of the cortical zones particularly in the left hemisphere. Dysfunction in this area as shown in perceptual asymmetry via dichotic listening may be a clue to severe reading dysfunction. The remark of Piercy (1964, p. 345) in reviewing the effects of cerebral lesions on intellectual functions is relevant:

> . . . neurological evidence suggests functional and anatomical differentiation of intellect with maturation and experience. Intellectual skills (as opposed to specific habits) become more focally organized in the brain of the growing and learning child and more readily dissociable from other abilities by cerebral lesion. Particular abilities may well vary in the degree of differentation acquired and in the age at which the major part of this differentiation is achieved; and there may well remain, after childhood, some degree of undifferentiated intellectual ability corresponding to Cattell's fluid ability or Hebb's 'potential for development.'

This is a reminder of Luria's double dissociations principle. Luria (1966a, 1966b, 1973) has drawn attention to the need to study the differential effects of different local brain dysfunction on both the processing and structures of mental activities and has proposed simultaneous and successive syntheses in information-processing. These basic issues will be developed in the next chapter.

CHAPTER 4

INFORMATION-PROCESSING IN READING AND ITS DIFFICULTIES

> It may be desirable to think of the stimuli used in any experiment as having dimensions in an 'information space' made up of all the dimensions discriminable on the sense organs.
>
> D.E. Broadbent, Perception and Communication, 1958.

4.1 Brains and Machines

It seems to be the Zeitgeist to compare higher mental processes, of which reading is one, to the working of machines. More than twenty-five years ago Wiener (1948) saw striking parallels between the computer and the nervous system, such as the apparent similarity of neurons and relays. The tendency to draw the analogy now is all the more irresitible, as computers with their versatile and wide-spread applications are here to stay. Up to a point, the brains and machines analogy is valid. Some of the all too well-known parallels include the ability for receiving and storing information and the capacity for solving problems. But there are also striking dissimilarities. For example, the high-speed with which the computer, once programmed, can solve problems and its large memory load for storing information far surpass those of the human. It can of course be said at once that since the efficient working of the machine depends ultimately on the ingenuity of man, the human is still superior. The often-voiced opinion that a computer can do only what it is instructed to do by a specific programme, though technically correct, is misleading. This does not imply the machine is not capable of divergent operations. The computer is known to be enabled to play a game of chess, and better than its programmer at that. In fact, one of the most ambitious and important developments over the past several decades is the versatile General Problem Solver (GPS) of Newell, Simon and associates (Newell, 1972; Newell, Shaw, and Simon, 1958; Simon, 1962, 1969, 1972; Simon and Barenfeld, 1969; Simon and Newell, 1962) to solve a variety of logical problems including proofs in trigonometry. An excellent and easily understandable account of man or rather the child as an information processor in a developmental context is given in a recent publication with chapters by Newell and Simon (Farnham-Diggory, 1972). It can again be said that if an analogy is drawn at all, it is more in the direction from machine to man as the "protocols" of the Newell, Shaw and Simon GPS are computer simulations of stages and sequences of human reasoning, rather than the other way round. There is one other often neglected point raised by Wiener (1948). Man as a processor can retain his experiences whereas it is possible to wipe the memory clean from a computer and reduce it to tabula rasa. Expositions in the preceding chapter have highlighted the complexities of the human brain and have pointed to the need for cautious interpretation of mental processes in strictly cybernetic terms.

It is against the above background that one should evaluate the information-processing model of reading dysfunction in the generally excellent NINDS Monograph by Chalfant and Scheffelin (1969). There is a further point that should be made in the man-machine analogy. While there have been successful attempts at visual pattern recognition (Neisser, 1967), efforts at devising computer programmes that will decipher the speech code have met with less than success (Cooper, 1972; Liberman, Cooper, Shankweiler, and Studdert-Kennedy, 1967; Mattingly, 1972). A tangible example of the former is the computer generation of Chinese characters in the Japanese Kanji component described by Fujimura and Kagaya (1969, personal communication). The complexity of the speech code, as outlined in the convergence of reading and speech in Chapter 2 (Section 2.6.2), has baffled work at building parsing programmes or machines to map acoustic invariants. This difficulty can be grasped if one attempts to read visual transforms of speech spectrograms, for example. For one thing, the spectrographic pattern for a particular phoneme looks different in different contexts. For another, segments corresponding to phonemes overlap one with the other (see Figure 2-3, Figure 2-4). This, however, does not imply spectrograms cannot be converted back to acoustic forms without much loss of intelligibility. Understanding of the speech code or what Mattingly (1972) calls linguistic awareness underlines reading dysfunction.

The ground thus cleared, there are merits in conceptualizing reading and its difficulties as information-processing. One is the possibility of regarding the reading act as a communication process comprising input, integration and output. Figure 4-1 schematically illustrates how auditory, visual and haptic stimuli are transmitted to the central processing mechanism (the brain) where they are analyzed, integrated and stored. The behavioural response of the subject serves as an additional source (feedback) for correcting or adjusting further behavioural responses. From a psycho-educational and clinical viewpoint the analogue has much to recommend itself. A more static variant of the

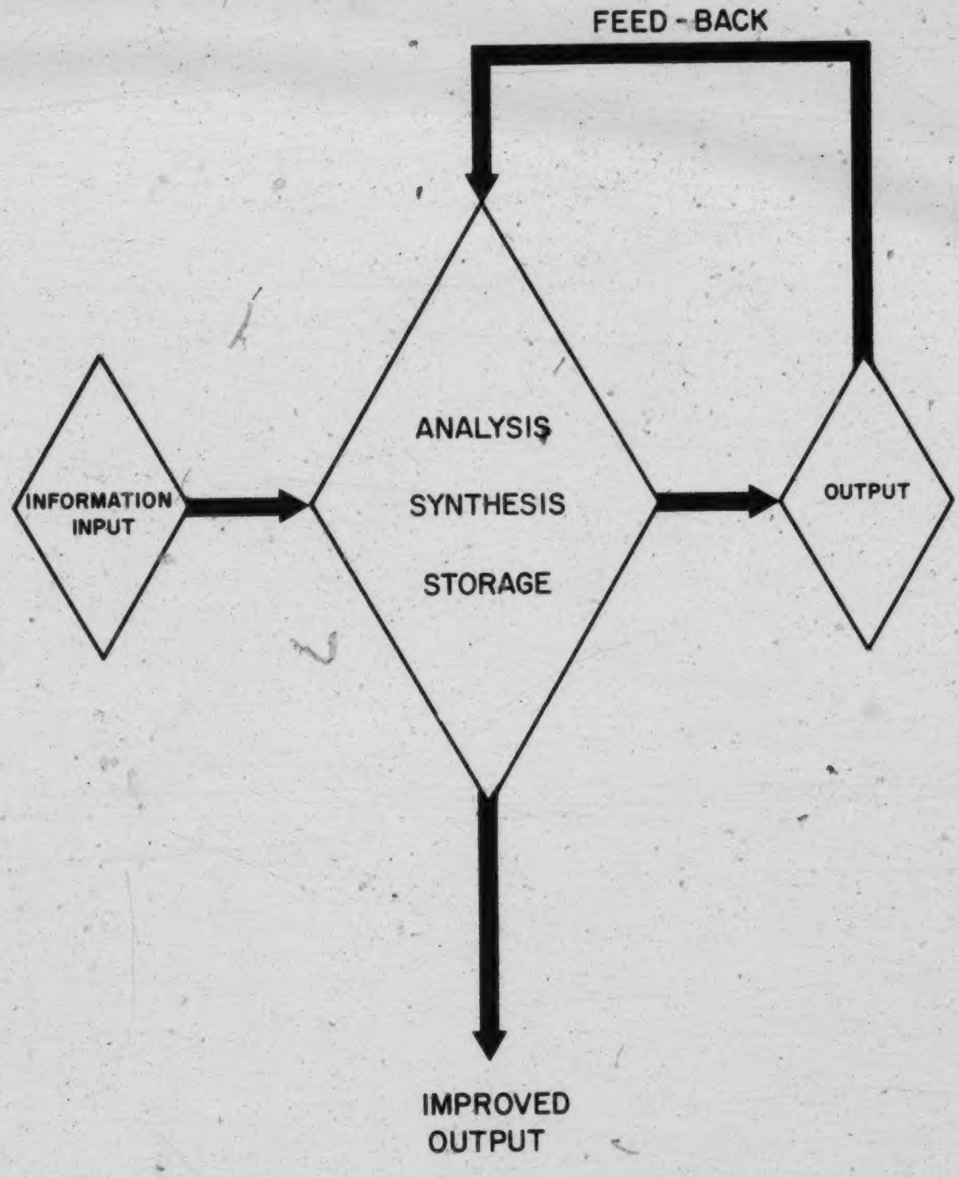
FEED - BACK
INFORMATION INPUT
ANALYSIS
SYNTHESIS
STORAGE
OUTPUT
IMPROVED OUTPUT

Figure 4-1. Schematic information-processing model applied to reading and its difficulties.

model may be found in the theoretical formulation of the Illinois Test of Psycholinguistic Abilities--ITPA--(Kirk and McCarthy, 1961; Kirk, McCarthy, and Kirk, 1968), which has been and still is used extensively by psychologists, speech clinicians and reading specialists since its inception as an experimental version in 1961 and as a revised version in 1968. The theoretical model of the ITPA, also derivable from the independently developed three-stage mediation model of Osgood (1957a, 1957b) and Wepman's (1953, 1967, 1968) CNS Operational model for aphasia, explains language learning in terms of: (a) processes of decoding, association and encoding; (b) levels of organization including a projection level, an integration level and a representation level; and (c) channels of communication, mainly visual and auditory in the case of language acquisition. Recently, there have been criticisms of psychometric weaknesses in standardization (Paraskevopoulos and Kirk, 1969) and the more valid one of lack of cognizance in the theoretical model of changes that have occurred in the last decade or so in developmental psycholinguistics (Leong, 1974b; Rosenberg, 1970). Also, Leong (1974a) has critically reviewed factorial studies on the ITPA. He has found from his own factor analyses (using principal component analysis, image analysis and alpha factor analysis with "reliability" checks) of ITPA results of moderately mentally retarded children that only the channel separation in the three-dimensional model is substantiated. Despite these statistical flaws the ITPA remains to-date a viable clinical instrument.

The second advantage of the computer analogue is in conceptualizing skilled readers as an efficient channel of communication and disabled ones as an inefficient channel. The skilled reader is able to use redundancy (in the information sense) inherent in read or spoken languages to gather information (see Smith, 1969, 1971). In a written language system there are different levels of redundancy in the orthography. There is the featural redundancy in individual letters, in clusters of letter strings, in word sequences and in combinations of word sequences. With disabled readers the high level of complexity of information presented to the eye (and via this to the brain) in reading may be independently developed. Experimental evidence for this has been presented in terms of bits of information by McLeod (1967) with tachistoscopically presented letter sequences and by Van Meel, Vlek and Bruijel (1970) with visual tasks involving varying discrimination dimensions. This possibility of using a meaningful common unit of bits/seconds holds appeal for some. However, estimates of human channel capacity in different tasks, or at different stages of practice, have not been altogether consistent. This finding may lead psychologists to re-examine the usefulness of this approach as commented on by Kahneman (1973).

A main advantage of the computer analogue is in drawing attention to the hierarchical nature of the skills underlying reading. The ease with which humans can perceive and classify visual patterns vis-a-vis the capabilities of machines should be noted. Computers can use a hierarchical process to identify, analyze, synthesize and classify certain critical features in printed symbols, as shown in the Fujimura and Kagaya (1969) computer generation of Kanji cited earlier. Likewise, Gibson (1966) has demonstrated that even seven-year-old children use a hierarchical classification tree when they are reading upper-case letters;

their method being only slightly different from that of adults.

In a theoretical paper on research into reading disability, Birch (1962) stresses the hierarchical organization of sensory systems differentiating different patterns of behaviour. Reading readiness, for example, consists in the organization of a hierarchical set of relations among the sensory systems where the "teleoreceptor" systems, particularly the visual (one would like to add auditory), become hierarchically dominant:

> . . . one of the problems which contribute to the development of reading disability is the inadequate development of these higher and more complex levels of visual perceptual function. Thus, we could predict that among those with reading disability one could begin to identify cases in which markedly defective analytic and synthetic visual perceptual capacity exists. . .
>
> (Birch, 1962, p. 169).

This view reinforces his earlier position paper that selective learning is better understood in terms of sensory integration rather than of stimulus-response connections (Birch and Bitterman, 1951) and finds endorsement in the NINDS Monograph (Chalfant and Scheffelin, 1969) alluded to.

From the computer analogue one can understand some of the theoretical underpinnings of research into visual deficiencies, auditory defects and visual-auditory integration or cross-modal difficulties found in disabled readers. A reasoned, up-to-date account of visual and auditory factors related to reading can be found in Vernon (1971) and will not be repeated here. In cross-model integration related to reading dysfunction, studies have been carried out by Birch and Belmont (1964, 1965), Birch and Lafford (1963), Blank and Bridger (1966), Blank, Weider, and Bridger (1968), Rudnick, Sterritt, and Flax (1967), Sterritt and Rudnick (1966), among others. Most of these studies follow the Birch and Belmont paradigm, with modifications and refinements. The samples studied are usually defined as above-average and below-average reading groups. The temporal-spatial integration tasks usually consist of rhythms, tones or taps and the visual patterns are either groups of dots presented simultaneously or temporally. Responses are usually same-different tasks on matching performance. The biggest single weakness of these studies, however, is in the loose experimental design with little control for experimental conditions and the small sample size. An exception is a recent study by Bryden (1972), which included rather rigorous design (three-way analysis of variance) and proper control for stimulus material intensity and timing for the auditory sequential and visual sequential patterns. This aside, very few studies seem to heed the exhortation of Bryant (1968), Milner and Bryant (1970) to distinguish cross-modality from within-modality effects. In general, results of the various studies show that backward readers are deficient in their abilities to perform cross-modal tasks and that there is a developmental trend in integrative abilities with rapid development between five and seven years of age.

While the findings are fairly consistent, interpretations differ. The explanation of verbal labelling or coding by Blank and associates to account for the difficulties of backward readers in matching a temporal sequential pattern of light flashes against dot patterns seem more forceful:

> One possible reason is that temporal patterns do not present themselves as a Gestalt; they can be coded only if the child independently imposes an organization on a series of evanescent events. Thus, the coding of purely temporal sequences represents a complex in which relatively high levels of abstract (verbal) categorization are essential.
>
> (Blank, Weider, and Bridger, 1968, p. 832).

The importance of strategies in problem solving will be detailed further on in this treatise. Also, temporal sequencing in relation to reading disability is a much neglected area which will be explored in subsequent sections and particularly in the context of dichotic listening.

4.2 Spatial-Temporal Coordinates--Lashley's Serial Order

In a search for the neurological spatial-temporal coordinates it would appear Lashley's (1951) celebrated Hixon Symposium on serial order organization might provide what Haber (1969) calls "converging operations" on reading dysfunction. Very briefly, Lashley rejects the associative chain theory in vogue at the time, which states in essence that individual responses in any serially ordered behaviour are under the control of proprioceptive feedback from the immediately preceding responses (Hull, 1943). Citing the fact that neurons of the Central Nervous System are continually bombarded by nerve impulses from various sources and are firing regularly, Lashley raises two specific objections to the chaining model. First, serial responses can be highly complex and the rapidity with which these are made leaves little time for the nervous system to conduct an impulse from the reception to the brain and back to the muscle. Secondly, in any well-organized temporal behaviour, the same response patterns may occur in a variety of different sequences. Lashley proposes a neural model for serial order that would provide a degree of flexibility and greater consistency with "what is known of the histology and elementary physiology of the brain and also with behaviour phenomena." The problem, Lashley feels, is how response elements can be activated in the proper sequence as the order is not determined by rigid connection between the trace system which determines the response. The trace systems involved in providing the response sequence can be simultaneously primed by some process of "attention" and then scanned by some mechanism independent of the traces. As an order system, traces can be associated with the body-oriented spatial reference system as well as with other traces. This "space coordinate system" provides a means of distinguishing otherwise identical traces so that they can be ordered in some manner. Thus, Lashley's view that sequential ordering is determined by a generalized, central, integrative process which is largely independent of and is imposed upon the specific acts or elements to be ordered appeared to imply a relatively late appearance of sequential ordering in the total learning process. Further, sequential learning may be conceived of as a necessary prerequisite to the development of symbolic representations.

Much of Lashley's (1951) discussion is concerned with language behaviour. He recognizes serial order as "the most important and most neglected problem of cerebral physiology (p. 114)," and that temporal integration is "especially characteristic of human behaviour and contributes as much as does any simple factor to the superiority of man's intelligence." He goes on to explain the essential problem of serial order:

> the existence of generalized schemata of action which determines the sequence of specific acts, acts which in themselves or in their associations seem to have no temporal valence.
>
> (p. 122).

He gives an example, "Rapid righting with his uninjured hand saved from loss the contents of the capsized canoe" to illustrate the importance of sequencing of these words, that accounts for their perception and understanding.

Lashley makes two further important points. He stresses that in cerebral functions "it is difficult to distinguish between spatial and temporal functions" as even in vision it is questionable whether simultaneous stimulation gives rise directly to space concepts and he goes on to state that:

> Spatial and temporal order thus appear to be almost completely interchangeable in cerebral action. The translation from the spatial distribution of memory traces to temporal sequence seems to be a fundamental aspect of the problem of serial order.
>
> (Lashley, 1951, p. 114).

The other point is that it is difficult to determine whether spatial or temporal order is primary. Thus Lashley argues much of memory is spatially organized and yet for even simple reproduction to occur it is essential to translate the images of memory into a serial order for their recall. This translation of spatial to serial order is a vexed problem and one that has plagued psychologists for a long time. Lashley's assertion should be compared with Luria's paradigm of simultaneous-successive syntheses, which throws some light on the problem from a different perspective. The operational basis for testing serial order is provided by the dichotic listening paradigm. Both these issues will be further clarified.

In connection with Lashley's much-quoted work, two reviews which bear on the present inquiry might be mentioned. One is a paper on "context-sensitive coding" by Wickelgren (1969) and the other is an extension of Lashley's spatio-temporal arrangements by Bryden (1967a). While endorsing Lashley's (1951) concept of serial order which conceptualizes words as coded as sequence of context-free elementary motor responses in the speech system, Wickelgren suggests the latter's rejection of the chaining model is premature as there are variant models which can be accommodated within the associative chain. One plausible theory is the "context-sensitive associative theory" which assumes that serial order is encoded by means of associations between context-sensitive elementary motor responses. In speech, this means that a word such as "stop" is assumed to be coded allophonically as /$\# S_t$, $s^t{}_o$, $t^o{}_p$, $o^{p\#}$/ rather than being coded phonemically as /S, t, o, p/. This wider interpretation of serial order is able to handle repeated item phenomena, coarticulation effects within words and across word boundaries and is more in keeping with current theories of speech perception (Cooper, 1972; Liberman, 1970; Liberman, Cooper, Shankweiler, and Studdert-Kennedy, 1967; Mattingly, 1972). As a generalization, it may be said that the Liberman model, the analysis-by-synthesis model of speech recognition by Stevens and Halle (1967) all have in common a listener actually participating in producing speech as well as in listening to it in order that he may compare his internal utterances with the incoming one. The unit of comparison probably has as its lower bound the syllable and for its upper bound, which is set by the capacity of short-term memory for auditory forms of the speech signal, the word or the phrase. This argument thus brings us back to the important aspect first discussed in Chapter 2 (Section 2.6.2) about the telescoping of segments of syllables and the parallel transmission of linguistic segments. In short, the notion of linguistic awareness underlying any linguistic performance.

Drawing from his experimental work in visual and auditory perception in relation to laterality, Bryden (1967a) operationalizes Lashley's concept of serial order. Rather than putting the entire onus on a central scanning mechanism as Lashley does, Bryden postulates three sources of neural activities as interacting to determine the response sequence. One is the immediate sensory input; the other is from transitory central processes ("set" experience) and the third is from more long-lasting central systems (learned associations). For example, the correct repetition of a short series of digits involves the sequential facilitation of the appropriate memory traces through their temporal components. Errors may arise because some memory traces may fade below the threshold before the subject gets round to reporting the stimuli and the temporal components become less and less destructive as more stimuli are presented. Bryden (1967a, p. 50) reiterated that:

> . . . the assumption that the memory traces excited by a series of stimuli have temporal components, and that the sequence is reproduced by successive facilitation of these traces through their temporal components provides a plausible mechanism for the reproduction of simple series.

Bryden further distinguihses between productive serial order and reproductive serial order. In productive serial order, the spatial and temporal components of the memory traces to be ordered cannot readily be identified by the experimenter, an example being extemporaneous speech. In reproductive serial order there is a fairly rigorous experimental control over the particular spatial and temporal relations between the inputs while the response sequence remains flexible. Bryden suggests that one way of investigating reproductive serial order experimentally is to present a number of stimulus objects simultaneously and to require sequential identification by the subject. Variations in stimulus input, experience and learned associations may then result in considerable variation in the response sequences used. Bryden singles out two particular experimental procedures--tachistoscopic exposure of distinct elements simultaneous for the visual modality and dichotic listening to test the simultaneous-successive coordinates for the auditory modality. Thus the Bryden paper both clarifies the meaning of serial order and further provides a means to test the concept experimentally.

4.3 Temporal Order Perception

Comparisons have sometimes been made between specific reading disability at its extreme form and developmental aphasia[1] as both exhibit similar symptomatology. Clinical observations show both dyslexic and aphasic children suffer from: (a) a defective storage system for speech signals; (b) selective impairment of discrimination and perception of basic linguistic units in phonetic contexts although these children may be able to discriminate between phonemes in isolation and (c) difficulty in receiving and processing auditory signals within the range of rate at which such signals are normally processed. (Eisenson, 1968; Luria, 1970b, 1972).

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[1] Strictly, the term aphasia should be restricted to adults. The terms "subclinical aphasia," "preaphasia" have been suggested for the form of language behaviour in children; and "congenital disorder in the acquisition of speech" and "congenital dyslegia" as alternatives to congenital aphasia.

There is a considerable body of evidence on this last-named temporal order perception by aphasics, although the implications for dyslexics have yet to be delimited. Hirsh (1959) suggested a separation of time between 15 and 20 milliseconds (msec.) is required for a listener to report correctly (75 percent of the time) which of two sounds precedes the other. He subsequently verified this with a light and a sound signal presented repeatedly in the same order and found similar results (Hirsh and Sherrick, 1961), although naive observers required about 60 msec. for the same accuracy of performance when the discriminating-sequencing situation was a single rather than repeated presentation of light and sound (Hirsh and Fraisse, 1965). In summing up the findings on the minimum time interval for awareness of succession of stimuli, Hirsh (1967) reports a figure as small as 2 msec. Fay (1966), in his valuable monograph on temporal sequence, reports from his survey of the literature that for sound clicks, successiveness can be perceived within a range of 2-10 msec. This is indeed fast listening.

For aphasics to discriminate between the successivity of two sounds, they need a much longer time interval than that cited above. Lowe and Campbell (1965) found, for example, that their aphasoid children need 55 to 700 msec. with a mean of 357 and a median of 350 msec. to distinguish between the serial order of two 15-msec. pulses, one at 2,000 Hz. and the other at 400 Hz. as compared with the range of 15-80 msec. with a mean of 36 and a median of 30 msec. on the normal controls. Lowe and Campbell (1965, p. 314) suggested that "temporal ordering malfunction of the aphasoid child . . . may be a major factor contributing to his communication problem." This is reminiscent of the point made by Monsees (1961, p. 83) that "the core of the aphasic disability is a disorder of the temporal sequence, auditory and perhaps visual." In reacting to Hirsh (1967), Efron (1967, p. 30) explains the implication of sequencing impairment in adult aphasics:

> We can thus consider it to be definitely established that aphasics as a group do suffer from a profound defect of auditory sequencing. What is not established is the relationship of this clearly defined deficit of auditory function to the understanding of spoken language. We now know that there is an _association_ between aphasia and this type of sequencing defect. It has not been proved that the defect in temporal sequencing is the primary _cause_ of the inability to understand speech.
>
> (author's italics).

Some pertinent questions may be raised. First, how is the perception of successive pure tones used in many of the studies related to the sequencing of speech sounds which have been shown to be complex codes not identifiable by discrete phonemes? Secondly, what is the implication for children with specific reading disability? With the avowed view from her "Procrustes' bed," Rees (1973) has drawn attention to the danger of unwarranted extrapolation from sequencing of discrete sounds to speech patterns and from studies on adults to children. She calls for a cognitive approach to "sentence structure." On the second question, there is some empirical evidence from the study of bisensory information-processing derived from Broadbent's (1956) dichoptic studies by Senf and associate (Senf, 1969; Senf and Freundl, 1971). Senf (1969) examines the memory for visual-auditory stimuli with normal and learning disabled boys varying in age from about 9 to 13 years. Of the several experiments reported the second is particularly relevant. Pairs of digits, one digit visually and one digit auditorily for each pair in this way V1/A2, V3/A4 and V5/A6 (V for visual and A for auditory) are presented to the children. Some are instructed to reproduce the digits by pairs (1, 2, 3, 4, 5, 6) and others by modality (1, 3, 5, 2, 4, 6), in both cases in the correct sequence of presentation. It is found that learning disturbed children make far more mistakes than normal children in reproduction in pairs and also in modality though for the latter task the differences between groups are greatest at younger ages. It is also found that learning-disturbed and normal children do not differ significantly with regard to the total number of digits that are reproduced correctly without taking into account digit sequence. From this it is clear that the perception and retention of the serial order of the digits, rather than the retention of the digits themselves, discriminate between normal and reading-distrubed children. Senf (1969, p. 27) observes: "This distinction is very important in that reading skills are heavily dependent on correct sequential ordering of events." Working within an information-processing model, Senf also emphasizes learning difficulties as higher order processes and the importance of redundancies as information-reducing devices (see also Attneave, 1959; Senf, 1972). Interpreting his results as general integrative problems rather than merely a specific auditory-visual, cross-modality deficiency, Senf also raises the pertinent question as to whether the deficit is due to memory storage problem or to the retarded readers failing to develop the ability to restructure the prevailing modality ordering of the stimulus array. In a further study in a different "sociocultural environment," Senf and Freundl (1971) confirm Senf's previous findings. Senf infers the involvement of higher order processes and the "decisive role" of auditory stimuli. The exact nature of this role is not clear. It may be that the "retarded" reader is less able to exclude auditory distraction or is stimulus bound by the aural input. Senf and Freundl suggest the need to study the immediate memory characteristics of disabled readers and emphasize the importance of time as a dimension for the organization of memory. The work of Senf further validates the importance of serial order and its relation to reading dysfunction.

Further important work comes from Bakker (1967a, 1967b, 1969, 1970, 1972; Bakker and Satz, 1970), who studies the relationship between temporal order perception and reading disability. The investigation is an improvement on the Blank and Bridger paradigm (Blank and Bridger, 1966; Blank, Weider, and Bridger, 1968) cast in the epistemological framework of time explication and the neuropsychological dichotic listening model. Bakker divides his groups into above-average (AA) and below-average (BA) readers with varying cutoff points. The concept of temporal order perception is predicated on the fact that temporal succession of the phonemes in the spoken word correlates to a high degree with the spatial succession of the graphic shapes in the written word. Bakker believes the ability to perceive, recognize and reproduce elements (digits, words) in serial order (first, second, third and so on) is an important correlate in reading or reading disability. Bakker finds the AA-readers obtain higher scores than the BA-readers with meaningful figures. Also, those children who are "mediators" or who appear to solve a problem by means of a verbal medium achieve the temporal ordering of meaningful figures better than the non-mediators, while the two groups do not differ with regard to meaningless figures. Bakker (1970) further shows that temporal order perception has a differential age effect with the suggestion that the perception and retention of temporal sequence significantly related to the age of 7 but not at the age of 10. Bakker offers the explanation that it is during this "transfer stage" (Fries, 1962) that the child learns to transfer from the auditory signals for language signals, which he has learnt, to a set of visual signals for the same signals. There is a temporal order perception threshold which functionally interacts with reading. Bakker (1970, p. 96) argues forcefully that:

> It is primarily when the verbal items are presented in a time scheme that disabled readers become differentially impaired. One might therefore conclude that both temporal order perception and verbal mediation represent necessary but not sufficient stimulus conditions by themselves. When both converge as requirements in a learning task, then disabled readers and aphasoid children may become differentially impaired.

Thus Bakker validates experimentally what Benton (1962, p. 86) expresses generally: "Again the question is raised whether one must not think in terms of an interaction of perception and linguistic deficits to account for this form of specific dyslexia." Here the perceptual deficit is temporal order perception and the linguistic deficit the deficiencies in verbal mediation. It is hoped this necessarily brief account would give an overall view of Bakker's ingenious and interesting work with reading-disturbed children. In a different vein, Fries (1962) discusses the role of linguistics in reading and stresses the relationship between temporal-spatial integration and the reading process. He observes that:

> All the signals of language as represented by auditory patterns are produced in a sequence--a sequence with a time dimension. A time sequence is inevitable in speech. . .
>
> (p. 121, author's italics).

This is also eloquently expressed by another eminent linguist Roman Jakobson (1967) who points out that speech, while mainly successive, is not merely linear. Broadbent (1958, p. 47) has this to say:

> . . . they [human beings] can use language because they can deal with sequences, and this in turn they can do because of their large nervous system . . . Speech is the most obvious case of stimuli being dealt with in sequences.

This highly condensed account of the successivity of speech embedded in a matrix must be seen in the context of the cognitive nature of reading as a language continuum, the experimental work at the Haskins Laboratories alluded to earlier and the spatial-temporal co-ordinates of Lashley referred to in the preceding sections. From his immense knowledge of neuropsychology and bedside clinical experience, Luria (1972, p. 38) sums up well that:

> . . . every stimulus begins to evoke a whole complex of reactions, and weak or unimportant associations are evoked with the same probability as strong or important ones.

and that speech is a "highly selective multidimensional matrix." Elsewhere, he (Luria, 1973, p. 306) makes it explicit that the structure of a word is a "complex multidimensional matrix of different cues and connections (acoustic, morphological, lexical and semantic) . . ."

(author's italics). An attempt will be made in the next section to clarify some of Luria's notions of multidimensionality as it relates to reading dysfunction.

4.4 Spatial-Temporal Integration--Luria's Simultaneous-Successive Syntheses

In his investigation into reading of aphasic patients Luria (1966a, 1970b, 1972) shows remarkable foresight and insight. His statement (1966a, p. 411) of the "process of fusion of the phonetic letters into words" and the influence of context on phonemes reminds one of Lashley's (1951) serial order, Wickelgren's (1969) context-sensitive association and Liberman and co-workers' linguistic awareness (Cooper, 1972; Liberman, 1970; Liberman, Cooper, Shankweiler, and Studdert-Kennedy, 1967; Mattingly, 1972). Luria's emphasis on the "complex comprehension" of reading can be understood by reference to his conceptualization of the "complex adaptive activity of a whole system" (Luria, 1966a, 1966b) and his double dissociation principle discussed earlier. In this regard, he proposes from his extensive and intensive study of patients with gunshot wounds and brain tumor two basic forms of integrative activity of the cerebral cortex: simultaneous (primarily spatial, groups) and successive (primarily temporally organized series) syntheses at the perceptual, mnestic and intellectual levels (Luria, 1966a, 1966b, 1969, 1970b).

Very briefly, simultaneous synthesis involves the synthesis of separate elements into simultaneous groups while successive synthesis relates to the ability of the cerebral apparatus to integrate external influences or their traces into successive series, distinguishable in time. Luria (1966a, 1966b, 1969, 1970b) identifies broad areas in the cortex mainly responsible for the different syntheses (Figure 3-2). In general, disturbance in the occipital-parietal area leads to difficulties with simultaneous-spatial groups. In particular, lesion in posterior (occipital-parietal) systems of the cortex explains the more disturbed simultaneous syntheses in the visual sphere and sometimes hardly in complex kinesthetic synthesis, while lesion to the parietal region (cortical and of tactile analyzer) leads to symptoms of disturbances in the tactile sphere. Damage to the fronto-temporal area which forms part of the motor and acoustic analyzers, is primarily associated with analysis of stimuli separated from each other in time and with their syntheses into successive series. Luria (1966b, p. 82) admits that the accumulated facts on the integration of stimuli are "fragmentary" and "not adequately systematized." He goes on to pose some relevant questions as to whether circumscribed lesions of different parts of the brain or groups of cortical zones cause disturbances of higher cortical functions, or whether "distinctive features of local lesions of the cerebral cortex" uniformly affect a group of analyzers at all levels of simultaneous and successively syntheses (Luria, 1966b, p. 82). Despite this, there is a clear parallel between Luria's successive synthesis and temporal sequencing. Luria (1966b, pp. 105-114) gives examples of specific difficulties in successive synthesis including: grouping of contextual verbal connections, smooth performance of serial form of activity (e.g., WISC Digit Span), the drawing of series of three elements in succession, named in a verbal instruction (equivalent of WISC Coding subtest). Luria suggests that performance in these problems is complicated by the need to retain the elements named in the instruction in a definite order and to switch over at the proper time from one stimulus to the next. He mentions that disturbance arising from lesion of the fronto-temporal regions of the left hemisphere "may be almost imperceptible." He emphasizes that people affected tend not to perceive stimuli as a "single kinetic melody" but as a group of isolated events:

> . . . these patients experience considerable difficulty in the perception, retention, and reproduction of serially organized acoustic signals and, in particular, of successive series of speech sounds and of words.
>
> (Luria, 1966b, p. 110).

Thus far, Lashley (1951) is vindicated, though from a different viewpoint. It should be noted that the perception, retention and reproduction of serial order form different hierarchical tasks, merging imperceptibly into one another. As with Lashley, the importance of speech sounds is stressed. In fact, Luria (1966b, p. 124) credits Lashley with describing "grammatical structures as the phenomenon in which this (the successive) type of synthesis is manifested" particularly clearly.

Recently, Das (1972a, 1972b, 1973a, 1973b) has proposed that the Luria model of simultaneous and successive modes of information-processing is a more parsimonious explanation of the traditional reasoning and memory factors in cognitive tasks and offers findings from principal component analyses to buttress his proposal. Das emphasizes that no hierarchy is implied between the two modes and points out that task complexity can be manipulated in each mode of information-processing. Luria (1966b) mentions specific tests at different levels of each mode of syntheses. For example, simultaneous synthesis at the perceptual level may be manifested in: copying of geometric figures, drawing of a map, performance on Koh's Block and at the mnestic level in: "arithmetic difficulties" and "grammatical structure involving arrangement of elements into one simultaneous scheme." In successive synthesis, examples are counting sequences of tapping, digit span and serial learning such as drawing "0 + + -" while keeping the correct order. This differentiation into different levels, while useful, seems to be too neat to account for a system which is actively excited and organized. Also, Luria's (1966b) implication that simultaneous synthesis is more related to visual-spatial tasks while successive synthesis to temporal-auditory events might be too restrictive a distinction as it is not so much the nature of the task but the strategy used in responding to the task that determines the mode of information processing. This implies that the solution of a task may include both successive and simultaneous processing and that it is possible to train for specific strategies in synthesis. Indeed, some evidence is provided for the possibility of changing strategies to maximise learning (Das, 1972b).

This flexibility seems to be more in keeping with cerebral functions which may not distinguish between spatial and temporal functions. This again reminds one that Lashley (1951) is emphatic on the integrative nature of spatial and temporal sequences. He suggests that it is possible for memory traces to be spatially distributed but for reproductive memory to be "invariably as a temporal sequence, either as a succession of words or of acts. Even descriptions of visual imagery . . . are generally descriptions of sequences, or temporal reconstructions from very fragmentary and questionable visual elements."

The need to integrate simultaneous-successive syntheses can be further understood from psychological studies of parallel and serial information-processing. For example, Sperling (1963) has argued that arrays of letters are stored in a visual short-term storage lasting several hundred milliseconds, after which they fade and all information is lost. However, during that time the contents of that storage are being translated item-by-item into a more permanent memory. He finds on the basis of several converging operations that the rate of serial processing of individual letters is about ten milliseconds per letter. In a recent version, Sperling (1970) proposes a model for the processing of information from an array of letters. The mechanism consists of these components: a visual memory with very high capacity and very short-term; a visual scan component that converts the representation of a letter in visual memory into the address of the motor programme for rehearsing the letter; a rehearsal component that converts the subvocal rehearsal into an auditory representation; an auditory short-term memory for the sound of the letter; and an auditory scan component that converts the auditory representation into the address of the motor programme for rehearsing the letter. Sperling (1970, p. 214) concludes from his experiments that:

> . . . information is gathered simultaneously--i.e., in parallel--from three or more letter locations at an initial rate of one letter per 10-15 msec. The visual system thus has, in principle, the capacity to analyze a word not letter by letter nor by overall shape, but from information gathered, in parallel, from its component letters.

Sperling, however, does not explain what he means by information gathered in parallel from the array of letters. In the auditory modality Broadbent (1958) used the dichotic listening technique to show that if a string of different digits arrives simultaneously to the two ears, the subject will report all of the ones from one ear and then report all of the ones from the other. The results suggest that while we may think we can listen to two conversations simultaneously (in parallel) we are in fact listening to one and then to the other (in serial). To this vexed question of parallel and serial processing we will return briefly in Chapter 10.

Support for Lashley's serial ordering as it relates to the reading process comes from different areas of work with children: from experimental child psychology and clinical psychology. Kolers and Katzman (1966) in testing the hypothesis that item identification and order reconstruction are distinct processes suggest that there are certain rates at which the subject can reproduce the items in correct order without always being able to name the familiar word the items spell. This result implies that synthesis of meaning is an even further serial processing occurring after item and order information is extracted. Kolers (1970) further suggests there is more to the perception of the letters in words than their shape and demonstrates the importance of "schematization" and subsequent filling-in as two aspects of correct word identification. He regards "disorder of seriation" as characteristic of learning disability, and errors arising from such disorder as due to the combination of a momentarily imperfect fixation on the end of a word and a slow regressive eye motion, or, alternatively, to a left word scan of an internalized image. He points out that disabled readers also perform poorly in other tasks involving seriation, and makes the "reasonable conjecture" that "there is a specific machinery of the nervous system concerned with the ordering of inputs and that this mechanism is defective in such people." (Kolers, 1970, p. 94). From his clinical experience with aphasics Wepman (1962) underlines the importance of temporal sequential processes in conceptual behaviour and language.

Again, one should be reminded of the multidimensionality of language that both Jakobson (1967) and Luria (1970b, 1972) refer to. Apart from the coordinate system that the simultaneous-successive modes of information processing maps, there is the possibility of testing the psychological reality of the constructs through factor analysis, despite the indeterminacy of some of the factor analytic models. In a position paper, McFie (1972) goes so far as to identify neurological correlates isomorphic with principal factors of psychological activities: frontal lesion corresponding to Thurstone's test of verbal fluency; left temporal lobe lesion to Wechsler's verbal reasoning factor because of impairment on Similarities and Vocabulary subtests of the WISC (McFie, 1960) and integrity of the hippocampus and mammillary bodies and their connections in the medial parts of the brain to long term memory (Milner, 1970). Luria is more cautious in his call for the use of factor analysis to map out psychological functions (Luria, 1970a).

4.5 Review

Without going into metaphysical problems of the kind "Is the human mind a machine?", or "Can machines think?" this chapter begins by conceptualizing reading and its difficulties as information-processing. Man is superior over machine in some ways (e.g., understanding of complex speech code and creativity); while machine, man in others (e.g., large memory load and high speed in problem solving when programmed). The cautiously drawn computer analogy highlights reading dysfunction as a communication process with disabled readers as a limited capacity channel and draws attention to the hierarchical nature of the skills underlying reading.

The importance of transducing of sensory information or intersensory integration leads to the consideration of Lashley's serial order and Luria's simultaneous-successive syntheses. Serial order, which underpins language behaviour, involves an interchangeable system of spatial and temporal coordinates. This flexible interpretation of parallel transmission of sequential linguistic segments finds support in studies of short-term memory and speech perception. The translation from the spatial distribution of memory traces to temporal sequence is verifiable via the dichotic listening paradigm. Related to serial order is temporal order perception which also provides a clue to the mechanisms underlining reading and reading dysfunction. Another viable approach to the understanding of complex functional systems in higher mental processes is Luria's simultaneous-successive syntheses at the perceptual, mnestic and intellectual levels. The construct of simultaneous synthesis (primarily spatial elements) and successive synthesis (primarily temporal, serial) as conceptualized by Das forms a mainstay of the present investigation. The chapter ends with the salutary reminder of the multidimensionality of the primarily sequential language elements.

PART II

AN INVESTIGATION

CHAPTER 5

A "PRINCIPAL COMPONENT" OF THE INQUIRY-- DICHOTIC LISTENING PARADIGM

> . . . One should not draw the frequently suggested but oversimplified conclusion that speech displays a purely linear character. It cannot be considered a unidimensional chain in time. It is a successive chain of phonemes, but phonemes are simultaneous bundles of concurrent distinctive features, and language exhibits various other structural features which prohibit regarding speech as mere linearity. Nevertheless, the predominantly sequential character of speech is beyond doubt, and this primacy of successivity must be analyzed.
>
> Roman Jakobson. In Wathan-Dunn, W. (Ed.) Models for the Perception of Speech and Visual Form, 1967, p.3.

5.1 Review and Preview of Research Rationale

It is shown in Chapter 2 that children with specific reading disability form a distinct but heterogeneous group from the continuum of poor reading. These disabled readers probably comprise about 1 percent of the school population. The investigation into some psychological characteristics of a well-defined group of nine-year-old disabled readers is based on two major premises--with both showing increasing promise in theory and application. One approach is largely developmental and the other largely cognitive with both rooted in the neuropsychological basis subserving reading as a language continuum.

The rationale for the developmental approach derives from the results of recent studies in those areas of experimental and clinical neurology and from experimental child psychology, which have emphasized the interaction of different dimensions of lateralization in normal development. Chapter 3 examines some of the relevant brain mechanisms. These include Geschwind's (1964, 1965, 1970, 1972) findings of structural differences in the two hemispheres and Luria's (1965a, 1966a, 1966b, 1970a, 1970b, 1972, 1973) complex functional systems accounting for the double dissociations principle. The Geschwind and Luria views explain the multidimensionality of language functioning and the "neurodynamics" of conjointly working cortical zones. Semmes and associates (Semmes, Weinstein, Ghent, and Teuber, 1960; Semmes, 1968) have suggested that the cerebral lateralization of speech stems from lateralization of motor and somatosensory functions culminating in the lateralization of speech. Semmes (1968) has proposed that each hierarchical functions are more focally represented within the left hemisphere in man. Lateral awareness should stabilize between six and twelve years and that speech (language) differentiation is achieved from about nine years onward (Benton, 1962; Lenneberg, 1967). Implicit in the concept of lateralization of language is the phenomenon of cerebral dominance or cerebral specialization for speech. Thus a clue to reading disability may be found in the slower lateralization of disabled readers compared with their normal reading peers. Recently, there is some evidence that cerebral lateralization may have a cognitive basis and is amenable to intellectual stimulation (Bever, 1971). The above explanation of cerebral dysfunction thus circumvents the nihilistic notion of dyslexia as a defect associated with organic pathology and suggests a more positive view of developmental lag with concomitant possibilities for remediation, if given in good time and properly programmed. The research paradigm owes to a number of sources: the early but prescient work of Orton (1925, 1937) on dyslexia;

the ongoing research on speech perception and hemispheric specialization of the Haskins Laboratories group (Kavangh and Mattingly, 1972; Liberman, 1970; Liberman, Cooper, Shankweiler, and Studdert-Kennedy, 1967; Shankweiler and Studdert-Kennedy, 1967; Studdert-Kennedy and Shankweiler, 1970) and in particular the ongoing research into dichotic listening and temporal order perception of disabled readers by Bakker in Amsterdam and Satz in Florida (Bakker, 1972; Bakker and Satz, 1970; Satz and Ross, 1973).

From the assumption of slower lateralization of disabled readers one is led to the intriguing problem of their pattern of performance in some "non-reading" tasks. Spatial-temporal tasks other than those which are "reading-related" are used, as by definition disabled readers are deficient in the latter. There is some suggestion that maturational lag of the left hemisphere and the corresponding lag in the functional specialization of language may confine the deficits to the mainly verbal areas and that performance in visual-motor tasks should be largely unaffected (Symmes, 1972; Symmes and Rapoport, 1972). On the other hand, there is stronger evidence that the whole matrix of spatial-temporal integration is impaired (Doehring, 1968) with a general deficit in auditory sequential processing of verbally codifiable materials (Bakker, 1972; Bakker and Satz, 1970; Doehring and Rabinovitch, 1969). A clue to the mechanisms of spatial-temporal integration is found in Luria's (1966a, 1966b, 1970b, 1973) neuropsychological paradigm of simultaneous-successive information-processing of mental processes from the perceptual, mnestic to intellectual levels. These physiologic findings and psychological methods for assessment are based on Luria's 50 years or so research and clinical observations of pathological cases. This neuropsychological approach with children is operationalized in the ongoing work of Das (1972a, 1972b, 1973a, 1973b).

These two approaches to specific reading disability--functional cerebral development with implicit language specialization and patterns of simultaneous-successive information-processing--raise a number of experimental and methodological problems. How is language lateralization tested? What is the appropriate experimental technique which taps the psychological manifestation of cerebral functions? Can the same technique together with other psychological tests throw some light on information-processing of disabled readers? These and other questions have led to the conception and execution of the present investigation as two independently-related main studies (see Figure 1-1). One main study consisting of three dichotic listening experiments converge more on language lateralization with implications for functional cerebral development. The other main study with two correlational sub-studies deal more with simultaneous-successive syntheses. The link between the two main studies is provided by the cerebral mechanisms inferred from the dichotic listening paradigm and also by the interpretations of the multidimensional spatial-temporal matrix from some "non-reading" tasks. Likewise, data analysis and statistical treatment should provide "converging operations" on both processes and products of some basic mechanisms of the phenomenon of specific reading disability. An attempt is made to incorporate both experimental and correlational studies that Cronbach (1957) made a strong plea for some years ago. This is not always easy as the two paradigms call for quite different experimental approaches with concomitant problems in sampling, statistical treatment and inferences. Within limits, the two approaches are accommodated in that the study on lateralization is largely analyzed with the analysis of variance model while the study on simultaneous-successive syntheses with the factor analytic model. It is hoped these divergent treatments will throw some light on both the strategies of disabled readers in solving perceptual, memorial and cognitive tasks and on the underlying constructs.

5.2 Dichotic Listening Models--Memorial and Perceptual

Briefly stated, dichotic listening is the experimental procedure of presenting different messages of stimuli (usually digits, letters or words) to different channels or sense organs (usually the two ears or the dichoptic analogue of the ear and the eye). The methods which have been used to separate one message from the other include the use of different people speaking, intensity differences, and the insertion of band-pass filters into the channel carrying one of the speech messages. The most effective cue has been found to be some form of spatial separation of the voices either by using different loudspeakers arranged laterally around the listener, or by using stereophonic earphones in which one voice is heard in one ear and one in the other. Unlike items which arrive from the babel-like auditory world of daily life, messages which are localized 180° apart as in dichotic listening do not stimulate both ears together. If the intensity level of dichotically presented messages is sufficiently low to avoid bone-conducted cross-talk between the ears and this, according to Moray (1969a) who quotes Zwislocki, would take place at about 70 dB r0.0002 dynes cm^{-2}, each message only stimulates one ear when dichotically presented. This deceptively simple dichotic procedure is usually credited to the experiments of Broadbent (1954), who in turn acknowledged his debt to the concurrent work of Cherry (1953, Cherry and Taylor, 1954). Similar experiments progressively refined have been replicated many times on different groups, with different research hypotheses and strategies and have generated a large volume of subsequent research relating to memorial and perceptual processes. In general, under free-recall conditions with verbal materials these results have been consistently found:

(a) If the material has been presented fairly rapidly, the subject tends to report all the numbers from one ear before reporting any from the other ear. This is referred to as the ear order effect.

(b) If the material is presented slowly the strategy commonly found is to report the material in the order of arrival (Broadbent, 1954; Bryden, 1962). This is known as temporal order of report.

There is an over-whelming body of evidence on the right-ear superiority for "verbal" materials in free dichotic recall (Bartz, Satz, and Fennell, 1967; Bartz, Satz, Fennell, and Lally, 1967; Bryden, 1966, 1967b; Cooper, Achenback, Satz, and Levy, 1967; Kimura, 1961b, 1964; Lowe, Cullen, Berlin, Thompson, and Willett, 1970; Satz, Achenbach, Pattishall, and Fennell, 1965; Shankweiler, 1966; Studdert-Kennedy and Shankweiler, 1970). A left-ear superiority is observed when "non-verbal" material is used (Bakker, 1967b; Kimura, 1964; 1973a; Shankweiler, 1966). The nature of some of these micro findings will be made clear in subsequent sections. Meanwhile, an exposition of two broad groups of models--one memorial and the other perceptual--to account for the differential performance of the two ears in dichotic listening will be presented.

Broadbent (1958) explains the successive processing of the simultaneous input of stimuli, as in dichotic listening, in information-processing terms. Information, according to him, is "the selection of one set of an ensemble of possible states at one stage by the occurrence of one of an ensemble of states at an earlier stage" (Broadbent, 1971, p. 7). For example, the perception of a word depends on the size of the vocabulary of other words which are possible at that moment; the correct judgment of the pitch of a tone depends on the other pitches being used. The quantitative component of the information processed is given by C where $C = \sum_{i=1}^{i=n} - P_i \log P_i$ for a system with "n" states and in which P is the probability of the i^{th} state. Broadbent suggests that the human perceptual system has a limited capacity, which operates selectively on all inputs and selects those inputs with common characteristics. This is most economical to the CNS and is regarded as a single channel for the latter (Broadbent, 1958, 1965).

Broadbent (1958, 1971) has proposed a filter theory to account for the variations in the order of report in dichotic listening as schematically represented in Figure 5-1. Briefly, Broadbent assumes a sequence of three elements: a short-term store (S-System) which he recently calls buffer store (Broadbent, 1971); a selective filter and a limited capacity channel (P-System). Concurrent stimuli which constantly bombard the senses enter the S-System in parallel, and they are analyzed there for physical or acoustic features. There is little or no definite limit on the capacity of the S-System. The selective filter allows those stimuli that arrive on a designated channel, which implies a discrete physical system with defined properties for which the filter can be set,

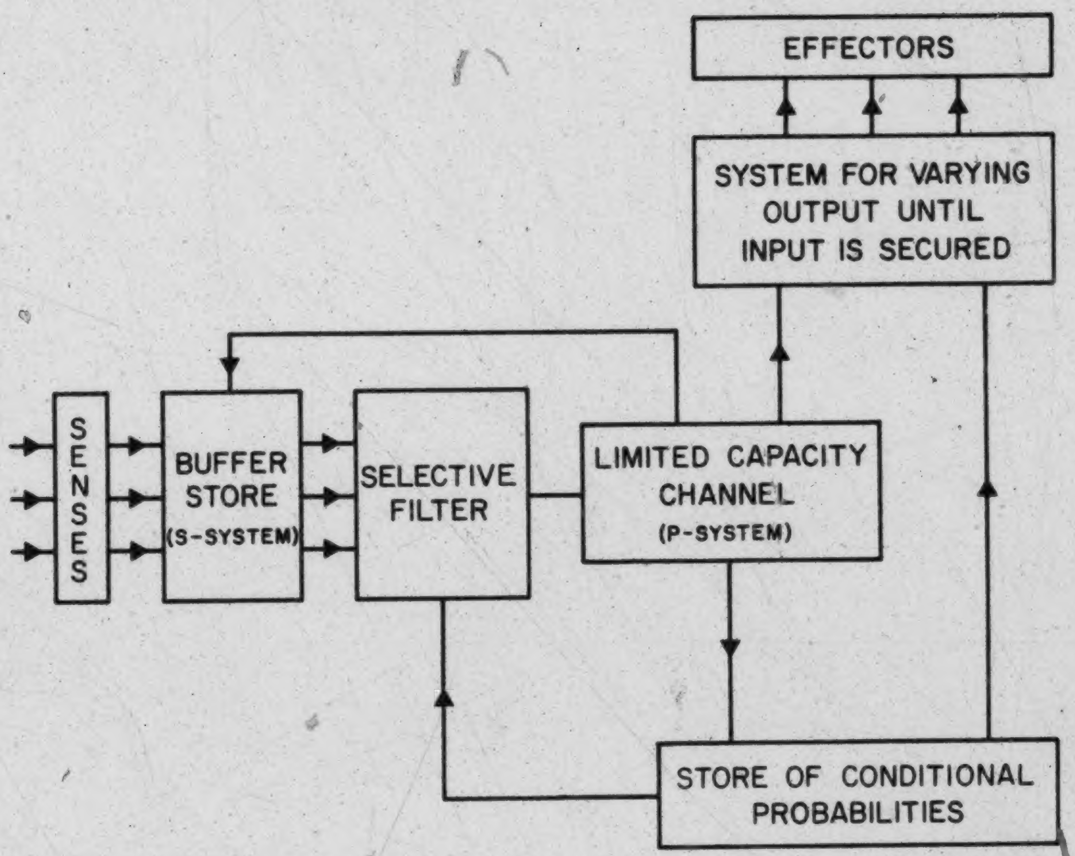
EFFECTORS
SYSTEM FOR VARYING OUTPUT UNTIL INPUT IS SECURED
SENSES
BUFFER STORE (S-SYSTEM)
SELECTIVE FILTER
LIMITED CAPACITY CHANNEL (P-SYSTEM)
STORE OF CONDITIONAL PROBABILITIES

Figure 5-1. Schematic information flow diagram of Broadbent (after Broadbent, 1958, 1971). "S system performs Parallel Processing; P system Serial Processing."

into the P-System. There more elaborate perceptual analyses are carried out. The P-System deals serially with accepted stimuli, and the time spent on each stimulus depends on the amount of information that the stimulus conveys. When the P-System has cleared, the filter permits a new stimulus to enter. Thus when dichotic stimuli are presented *simultaneously*, they can be handled *successively* only if the processing of the first is completed before the record of the other in the S-System has decayed. Thus the filter theory postulates the importance of input and that attention cannot be divided as the P-System performs no parallel processing of discrete stimuli. Any deficiency in either the S- or the P-System would lead to general learning deficiency. Retardates or learning disabled children might suffer from an impaired S-System, or alternatively their capacity of the P-System is restricted so that they can attend to less information at any one time. In a typical dichotic listening experiment at a fast rate of presentation, the subject cannot switch attention from one channel to another fast enough to perceive both numbers, and thus adopts the ear-order strategy. At the slow rate of presentation, the subject has enough time to shift attention from one channel to another, and thus can report materials in the order of arrival. This highly condensed version of the influential Broadbent information-flow theory gives the gist of the theoretical basis of dichotic listening experiments.

There have been, however, alternative explanations to the filter theory some of which can be briefly stated. Neisser (1967) suggests that selective attention consists of the allocation of a limited capacity to the processing of chosen stimuli and to the preparation of chosen responses. To Neisser perception is an active process of analysis-by-synthesis, the meaning of which has been explained in earlier sections. Neisser's concept of echoic and iconic memory as well as Sperling's Visual Information Storage (VIS) and Auditory Information Storage (AIS) are derivable from Broadbent's pre-perceptual memory (S-System). For Treisman (1960, 1964, 1969), filtering is not an all-or-none process; the unattended message is attenuated and not rejected and that attended and unattended stimuli are differentially treated. Treisman further proposes that a single input can be processed by several analyzers in parallel while the processing of two inputs by the same analyzer must be serial. The Treisman filter-attenuation modification is accepted by Broadbent (Broadbent and Gregory, 1964). The more important theoretical aspect of undivided and divided attention and the possibility of parallel processing as an alternative to the serial processing of simultaneous stimuli is beyond the scope of this treatise, although a few comments will be made in Chapter 10. To critics of the Broadbent filter theory suffices it to say that the model provides a useful approximation to what people usually do, if not entirely what they can do, in processing information.

Besides Broadbent's filter theory and information-flow model, models emphasizing perception or cerebral asymmetry have been proposed to account for the dichotic listening phenomenon. In a position paper Bryden (1967b) evaluates four such models: the order-effect model of Inglis (1965) together with its variant differential-storage model; the perceptual model of Kimura (1961a, 1961b, 1963) and Bryden's own perceptual-threshold model (1967b). A schematic representation of the models is presented in Figure 5-2 and an evaluation of Bryden's evaluation follows.

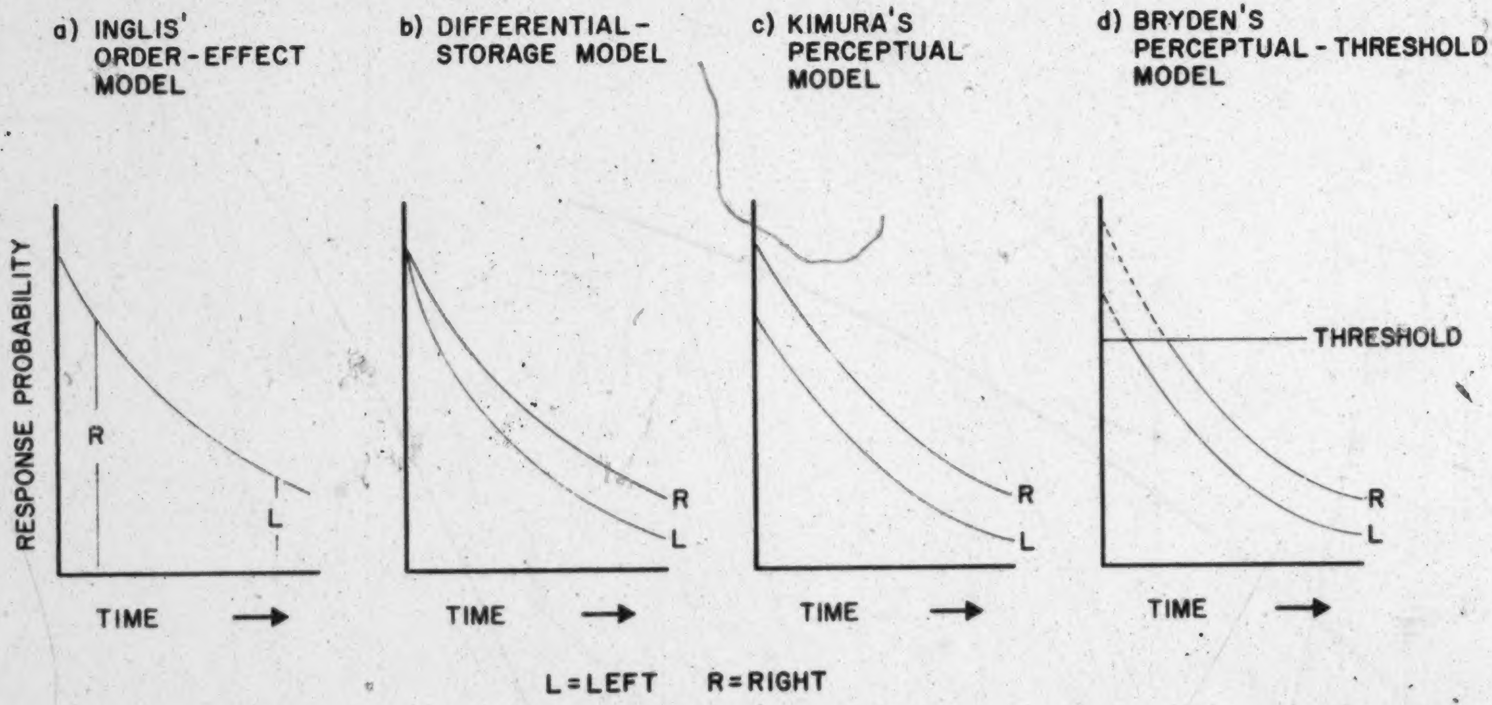

Figure 5-2. Four models for laterality effects in dichotic listening: (a) order-effect model, (b) differential-storage model, (c) perceptual model of Kimura, (d) perceptual-threshold model of Bryden. The horizontal line indicates the minimum amount of neural activity needed for a perfectly correct response. (From Bryden, 1967b, with permission.)

In the order-effect model diagrammed in Figure 5-2a Inglis (1965) suggests both half-spans have entered (different) storage systems, but the delayed half-spans have been held in store longer and have been subject to more recall interference, hence more error appears. In other words, recall accuracy increases as a function of time since input and the right-ear superiority is due not so much to a more accurate perception of material arriving at the dominant hemisphere, but to the bias in the order of report. The differential storage model (Figure 5-2b), a variant of Inglis' paradigm, attempts to show that lateral asymmetries will increase as a function of time between storage and recall and postulates in an ordered-recall situation that there will be little or no difference between accuracy on the left ear when it is given first and accuracy on the right ear when it is given first. While the explanation of both these related models, which straddle the perceptual and memorial domains, is plausible, it does not wholly account for right-ear superiority in dichotic tasks. Moreover, experimental results such as that provided by Inglis and Sykes (1967) to verify the hypotheses have not been unequivocal.

In the perceptual model (Figure 5-2c) of Kimura (1961a, 1961b, 1963, 1973a) right-ear superiority is expected with both free and ordered recall procedures and applies to both the immediate channel and the storage channel. This means that the right-ear material, reported first, should be given more accurately than the left-ear material, reported first. Similarly, the right ear material, reported second, should be given more accurately than the left ear material, reported second. Drawing from her theoretical knowledge and practical experience with pathological cases, Kimura (1963, 1973a) explains lateralization differences as due to the stronger contralateral neuro-pathways from the right ear to the left hemisphere which is specialized for speech. A fuller explanation has been presented in Chapter 3 (Section 3.7) and illustrated schematically in Figure 3-3.

Bryden's (1967b) perceptual threshold model which is schematically represented in Figure 5-2d seems to provide a more parsimonious explanation of lateralization effects. The model buttressed with some experimental evidence emphasizes a perceptual difference rather than a storage difference and suggests that memory traces set up by the input must fall below a certain threshold before any errors are made. In other words, a right-ear superiority will not appear on the immediate recall channel until the task is made sufficiently difficult to produce some errors on that channel. There is some evidence for the suggestion that lateralization effect is a function, under certain conditions, of task difficulty (Satz, 1968; Satz, Achenbach, Pattishall, and Fennell, 1965). But neither Bryden explains explicitly, nor other workers cited do, what is meant by "task difficulty." Could it be variation in rate of presentation? In series length? Or in both? For a more satisfactory answer attention must be turned to studies on hemispheric specialization and speech perception.

The Broadbent filter theory and the cerebral asymmetry paradigm are discussed at some length as they both provide the theoretical underpinning to dichotic listening tasks. There seems to be a tendency in research to explain a phenomenon with one paradigm without due accommodation for rival ones. With dichotic listening the models presented are complementary. One should take an eclectic approach and examine the merits of each of the models. It is therefore not to the point to ask which is the better model. If one has to express a preference on the evidence available, the perceptual model generally provides a sounder explanation. Sounder perhaps more from recent speech perception research, apart from neuropsychological considerations already mentioned. This is another way of saying that the studies discussed thus far dealt less with micro questions of the exact nature of speech perception. This will be taken up briefly. The vexed question of the contribution of perception and memory to differential ear effects is one of the research questions to which the present inquiry is addressed. Perhaps the results will show whether the equivocal answer will be made less unequivocal.

5.3 Aspects of Current Dichotic Speech Perception Studies

The extent and nature of studies emanating from the dichotic listening paradigm from the early 1960's to early 1970 can be gleaned from a bibliography prepared by Richardson and Knights (1970). The list draws mainly from sources in experimental psychology and to some extent from neuropsychology with some mention of work in the speech perception field. From this source and from a further study of related literature in the last ten years or so, it can be seen that in general work relates mostly to the testing of the filter theory and cerebral asymmetry models with the view to refining and delimiting some of the crucial variables involved. The large volume of work substantiating the right-ear superiority with verbal materials has been mentioned, and will not be further cited. Dichotic listening has been studied in relation to normal and pathological brain function (Kimura, 1961a, 1961b; Milner, Taylor, and Sperry, 1968; Schulhoff and Goodglass, 1969); lateralized brain damage in early childhood (Goodglass, 1967); stuttering (Curry and Gregory, 1969); handedness (Curry, 1967; Curry and Rutherford, 1967; Dee, 1971; Knox and Boon, 1970; Orlando, 1972; Satz, 1968; Satz, Achenbach, Pattishall, and Fennell, 1965; Zurif and Bryden, 1969; Zurif and Carson, 1970); selective listening ability and developmental trend (Inglis and Caird, 1963; Maccoby, 1967; Maccoby and Konrad, 1966, 1967; Treisman and Geffen, 1967; Treisman and Riley, 1969); and very recently speech lateralization and overt motor (hand) activity (Kimura, 1973a, 1973b, 1973c). Different groups of exceptional children have been investigated in their perceptual and memorial processes via dichotic listening tasks: mentally retarded children (Jones and Spreen, 1967; Neufeldt, 1966); hearing impaired children (Ling, 1971); high and low achievers (Conners, Kramer, and Guerra, 1969) and disabled readers (Zurif and Carson, 1970).

The above reference source, while comprehensive, does not sufficiently emphasize at least two important current developments in dichotic listening. One aspect relates to the more microscopic dissection of components of speech stimuli in relation to hemispheric specialization. The other aspect to temporal order perception via dichotic listening with disabled readers. The first-named area--dichotic speech perception--is largely associated with the excellent ongoing research of the Haskins Laboratories (Shankweiler, 1971; Shankweiler and Studdert-Kennedy, 1967; Studdert-Kennedy and Shankweiler, 1970; Studdert-Kennedy, Shankweiler, and Pisoni, 1972); other speech/hearing research centres (Berlin, Lowe-Bell, Cullen, Jr., Thompson, and Loovis, 1973; Dobie and Simmons, 1971; Lowe, Cullen, Jr., Berlin, Thompson, and Willett, 1970) and to a lesser extent with some psychological laboratories

(Bryden and Allard, 1973; Wilson, Dirks, and Carterette, 1968). The second-named aspect of dichotic listening in the spatial-temporal matrix evolves round the work of Bakker (1967b, 1969, 1970, 1972, 1973; Bakker and Satz, 1970) and has been discussed in Chapter 4 Section 4.3 under the heading of "Temporal Order Perception."

The first group of studies dealing with the "speech processor" in the left hemisphere in acoustic-signal-vocal-trait control functions is of more tangential interest to the present inquiry. This does not mean the studies are not relevant. In fact, they are important for at least two reasons. First, they demonstrate experimentally and empirically the complexities of acoustic signals in dichotic listening and that stop consonants and vowels are differentially perceived and lateralized. This delineation of the exact nature of the right-ear superiority with varying verbal materials, now taken for granted, is all too slowly realized and pursued by workers using the dichotic paradigm. Secondly, the studies point to future research needs and directions including those for more sophisticated techniques in dichotic tape preparation (given the equipments); clearer delimitation of problems and more refined data analyses. In this regard, the studies in this group as a whole are sound in their conception; relevant and precise in their methodology and logical and far-reaching in their discussions. The same, however, cannot be said of some of the earlier studies where loose experimental designs are employed and extrapolations unwarranted by the data made on the nature of the memorial and perceptual processes. Moreover, the Haskins results in particular have practical implications in remediation. One relates to the advisability or otherwise of wide-spread practices in training in non-speech sounds for reading improvement in view of the findings of differential processing in the hemispheres of speech and "non-speech" elements; and the other emphasizes the importance of the aforesaid linguistic awareness advocated by I. Liberman and associates (Liberman, 1971; Liberman, 1973; Liberman, Shankweiler, Carter, and Fischer, 1972; Liberman, Shankweiler, Orlando, Harris, and Berti, 1971; Shankweiler and Liberman, 1972). The full import of these works will be discussed particularly in Chapter 10 (Section 10.2)

In view of the significance of the analytic work of differential realization of speech stimuli in dichotic listening, some of the major findings may be mentioned. The earlier molar result of Kimura (1964) that non-verbal stimuli such as musical melodies, are more accurately reported in the left ear have been subsequently confirmed (Spellacy and Blumstein, 1970; Spreen, Spellacy, and Reid, 1970). More molecular results clarifying the "verbal" and "non-verbal" nature of speech stimuli have come from researchers at the Haskins Laboratories. Shankweiler and Studdert-Kennedy (1967) offer evidence that left hemisphere dominance in speech perception operates at the level of speech sound structure and this effect is greater for consonant-vowel (CV) pairs differing on two articulatory features than for pairs differing cn one. They show that synthetic steady-state consonants([b, d, g, p, t, k] used) are better realized with right-ear presentation and synthetic steady-state vowels ([i,ɛ ,ɔ ,æ ,ɝ , u] used) by left-ear presentation. The full import of theirs and other extended research in this line can be realized from at least these four excellent technical papers replete with conceptual and methodological refinements: Berlin, Lowe-Bell, Cullen, Jr., Thompson, and Loovis (1973), Studdert-Kennedy and Shankweiler (1970), Studdert-Kennedy, Shankweiler, and Pisoni (1972) and in an easily understandable account by Shankweiler (1971). Very briefly these results are found:

(a) Stop consonants and vowels in both synthetic and natural speech are further confirmed to be differentially perceived. The right-ear advantage (R) over the left-ear (L) for these consonants and vowels in terms of laterality indices as given by (R - L/R,+ L) x 100 is graphed in Figure 5-3. It can be seen /b/ and /g/ have the highest indices and the voiced consonant at a given place value is always higher than its unvoiced counterpart. The right-ear advantage for all consonants is strong and consistent while lateralization for the vowels is weak and inconsistent. The Haskins Laboratories researchers, however, also hypothesize that reduced, rapidly articulated, "encoded" vowels embedded in CVC syllables might possibly show a significant right-ear effect.

(b) For the consonants the articulatory features of voicing and place of production are separately extracted and processed, with the voicing values more accurately identified than place values. These results are based on the two voicing (voiced, voiceless) and three place (labial, alveolar, velar) matrix of trials and also on analysis of confusion matrices.

(c) Agreeing almost precisely with the above findings from the Haskins Laboratories, Berlin, Lowe-Bell, Cullen, Jr., Thompson, and Loovis (1973) have found further in their experiments, also painstakingly designed and executed, that when one of the CV's trails the other by 30-60 milliseconds the trailing CV becomes more intelligible, regardless of which ear being stimulated although overall right ear still tends to do better. To overcome this lag effect with voiced/voiceless CV pairs,

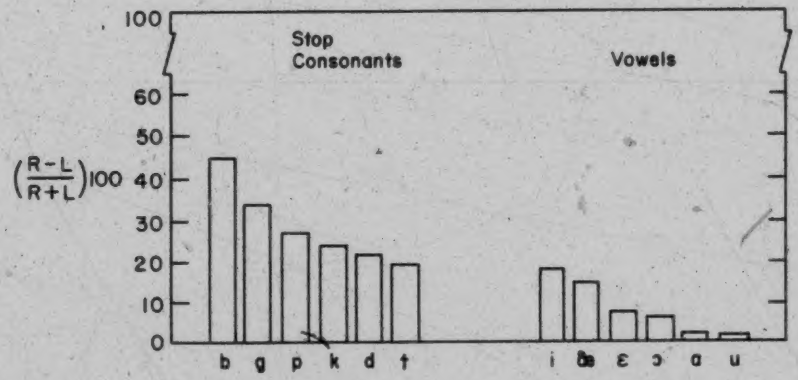

Figure 5-3. The right ear advantage for individual stop consonants and vowels (after Shankweiler, 1971; Studdert-Kennedy & Shankweiler, 1970).

Berlin and co-workers suggest aligning syllables by "excitation change" as shown in oscillographic tracings rather than on precise simultaneity of onset.

As a synthesis, the recent dichotic perception studies outlined above have added a new dimension to our understanding of hemispheric specialization. Briefly stated, the auditory system common to both hemispheres is probably equipped to track formants and in general to extract the auditory parameters of speech. But it is the left hemisphere which is largely responsible for linguistic interpretations such as the selection from the auditory system those elements relevant to the perception of voicing and place of articulation. In line with the findings discussed in Chapter 3 (Kimura, 1973a; Milner, Taylor, and Sperry, 1968; Sparks and Geschwind, 1968) laterality effect is also due to the loss of auditory information arising from inter-hemispheric transfer of the ipsilateral signal to the dominant hemisphere for linguistic processing as illustrated in Figure 3-3.

While such applications of dichotic listening tasks with disabled readers as those of Bakker (1967a, 1969, 1970, 1972, 1973; Bakker and Satz, 1970), the speech perception studies have alerted us to the complexities of dichotic stimuli. As the dichotic paradigm depends for its results on very rigorous experimental and stimulus control, which often eludes psychologists, there is reason to better understand some of the methodological problems and attempt to overcome them.

5.4 Relevant Technical Problems in Dichotic Tape Preparation

For an individual researcher pursuing dichotic listening studies but lacking proper facilities, the preparation of tapes to rigorous technical specifications alone is a formidable challenge. The satisfaction in rising to the occasion is therefore all the greater. Among other things, at least two main obstacles have to be overcome:

(a) The establishment of onset synchrony between pairs of stimuli fed into left and right ears respectively (and possibly offset simultaneity as well, as suggested by some workers).

(b) Control of intensity and signal-to-noise parameters to provide acoustic channel equality.

These aspects are illustrated schematically below:

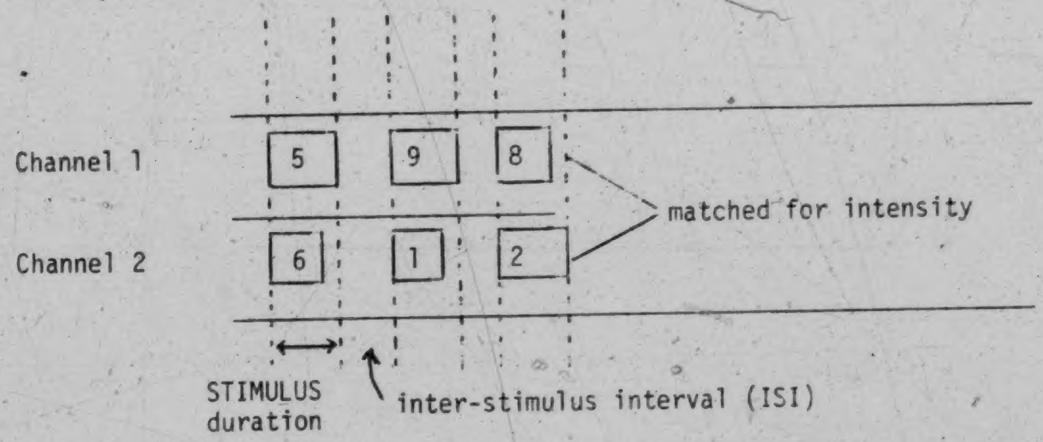

Figure 5-4 Schematic representation of onset, duration in dichotic listening for a three-digit pair (three-digit series, each digit paired or synchronized with the corresponding one.)

It is all too obvious that synchrony of onset is vital as lack of it may direct the subject's attention to that ear where the stimulus arrives first. But what does synchrony or simultaneity mean? How is synchrony differentially affected by consonants, by vowels and by their acoustic environment particularly in view of the fine-grained studies by the Haskins group as explained in the preceding section? Does the lag effect found by Berlin et al (1973) and Lowe et al (1970) suggest a different approach to onset synchrony? How is synchrony achieved in the preparation of the dichotic stimulus tape? How is the inter-pair interval measured (if verified at all)? From the end of the final releases of the syllable with the shorter duration or that with the longer duration? What exactly is meant by the rate of so many pairs per unit time such as 2 pairs/ear/second so often used? These and others are some of the formidable problems encountered in dichotic tape preparation. Many researchers working within the paradigm rarely report their method of tape preparation and explain how "dichotic" their dichotic tapes are. Yet on the satisfactory solution of the technical problems posed above depend the result of any study, as emphasized by Yates (1972), among others.

From reading of the literature from various disciplines and through personal communication with one or two workers, some insight is gained into more precise methods of dichotic tape preparation. The deceptively simple procedures pioneered by Broadbent and Kimura are indeed ingenious even with today's sophistication. Broadbent apparently uses a metronome to gauge simultaneity. Kimura places a guide mark on the tape deck and the tape itself to help judge the distance and hence time interval between signals. Each stimulus signal on channel 1 of the tape is recorded as soon as the mark on the tape passes the guide mark on the face plate of the recorder and the same procedure is used to record each stimulus on the other channel of the tape when the latter has been rewound. In this way and after checking by listening to the pairs of stimuli recorded, and re-recorded if necessary, approximate simultaneity is achieved. From these early attempts have evolved more sophisticated techniques.

To the present writer's best knowledge, of the considerable literature on or related to dichotic listening only a few studies give a reasonable description of the procedure of constructing dichotic tapes. Three of these studies are published papers (Rubino, 1972; Studdert-Kennedy and Shankweiler, 1970; Yates, Smith, Burke, and Keane, 1969) and two are as yet unpublished (Carr, 1969, personal communication; Irvine, 1972). However, it is difficult for a number of reasons to construct dichotic stimulus materials on the basis of whatever details there are from these works. Moreover, the writer would like to use his own instrumentation and explore a method which is both technically sound and administratively practicable.

The basic idea of tape construction of these workers is as follows. A phonetician or an experienced speaker is trained to utter the stimulus signals, say digits, at an even intensity (monitored on a VU meter) and to release the final stops. Each digit is recorded a number of times and the recordings are played through a Bruel and Kjaer sound pressure level recorder to obtain a record of the intensity of each digit. One example of each digit is chosen so that the final list contains only digits of about the same intensity. The latter is defined as RMS pressure values over the syllable. The duration of each digit is measured on a spectrogram or an oscilloscope. From the present writer's experience, the duration for the digit 0 (pronounced zero) to 9 ranges from about 350 to 500 milliseconds (msec.). This compares with the finding of Yates, Smith, Burke, and Keane (1969) of variations between 407 and 553 msec. and with that of Studdert-Kennedy and Shankweiler (1970) of a range of 300-500 msec. for natural CVC syllables. Some variation is needed for maximum intelligibility as digits or syllables have natural acoustic durations. With both intensity and duration under fairly rigorous control, each digit in the final list of the tape is cut out and spliced into a tape loop. Thus far, the procedure seems clear-cut, and there is general agreement amongst the workers as to the sequential steps to follow. The operation, however, is both arduous and time-consuming.

The next and the most important task of transcribing the already carefully selected digits on the tape loop to the two tracks of another tape to achieve onset synchrony is singularly difficult. From what can be abstracted from the studies cited, three stereophonic tape recorders are generally used. Very briefly, digits for track 1 are played through the first tape recorder while digit for track 2 through the second recorder with both track 1 and track 2 digits feeding into the third recorder for the final tape. A control time device linked to the recorders can effect time alignment adjustment. Synchrony is achieved by setting the third tape transport in motion slightly ahead, through the control device, when the first two tape recorders are still in the "pause" position and then releasing these simultaneously. This procedure allows the two digits to be recorded, one on each channel of the third tape recorder, with reasonable synchrony. As a specific example, Carr's (1969, personal communication) method, in the writer's opinion, is the most efficient. In essence, his procedure consists in recording one set of digits on channel 1 of a dual channel tape recorder and another set of digits on a second recorder. The material on channel 1 of the first recorder is then used to activate the second recorder which would then direct its digits to the first recorder where they would be recorded on channel 2 in synchronization with the set of digits already on channel 1 of that recorder. In order to accomplish this, a recorder with remote control facilities and the capacity for starting, running up to speed and stopping almost instantaneously is needed. In addition, a special cuing device for automatic activation and stopping of the second recorder upon sensing of external voice impulses is essential. Carr (1969) reports his paired signals on his tapes show much improved synchrony when compared with a more traditional method of recording. In his recent personal communication with the present writer, which dates from early 1972, Dr. Carr suggests there is probably a simpler way to achieve synchrony to within 30 msec. This, however, remains to be tried out and tested.

In summary, the procedure of constructing dichotic tapes is as follows:

(a) "Tryout" recording of test materials on to tapes with due regard for intensity and duration of the stimuli.

(b) Splicing of "best" stimuli from tryouts on to a master tape loop.

(c) Re-recording of "best" stimuli from tryout or from the master tape loops through some kind of time control device to achieve synchrony on the final tape.

In actual practice, these steps, particularly (a) and (c) are extremely arduous and time-consuming. For example, the check of duration through a spectrogram and more conveniently through an oscilloscope is often difficult. The excursions above noise level for different phonemes embedded in different acoustic environment vary and make for difficulties in determining onset synchrony. The splicing of tapes can be a frustrating experience for the novice. What is more difficult is that the few writers on methodology are often less than explicit in their details, particularly in the vital step (c). Rubino's (1972) method, though fairly detailed, raises some grave doubts in the writer's mind as to the claim of onset synchrony of less than 5 msec. in the final tape. The minor flaw is his use of a tape speed of 1 7/8 inches per second (IPS) which reduces sound fidelity. The major flaw is the reliance on the "instant stop" buttons for recording and the monitoring by ear to decide on the precise moment for disengaging the buttons to begin transcription. Thus the very refined 5 msec. onset difference between pairs of stimuli is more characteristic of computer-controlled instrumentation. Irvine's (1972) method seems to achieve reasonable results but could do with more details explaining the precise procedure. In neither case is there any indication of the technical quality of the final tape, save the claim the synchrony is achieved. Of these several works cited, Carr's is the most efficacious, but it involves the construction of a special cuing device. All these remarks, however, are meant as a tribute to, rather than a criticism of, the ingenuity of these and other workers. The present writer has benefited by their results and in particular from the advice and generosity of Dr. Burchard Carr in the continued correspondence over the past several years. On the basis of this accumulated experience it is hoped to find a way to construct dichotic stimulus materials more expeditiously and with even greater precision. Perhaps the ultimate for synchrony lies with the use of computer-controlled or computer-generated list of digits such as the digitized form in a PDP-6 computer mentioned by Yates (1972) and as is the practice with the Haskins Laboratories work.

5.5 Dichotic Tape Preparation--Experimentation and Methodology

This section explains the basic idea followed and the instrumentation used by the present writer for the construction of dichotic tapes. The essential apparatus consists of: (a) Two high-quality dual channel tape recorders with solenoid operated run and record functions and with tape lifters that can be defeated when the machine is in stop mode. The two matched Sony 777-4J (Figure 5-10) used in the investigation have been found to be most satisfactory.

(b) A specially designed and constructed cuing or control device[1] for precise time alignment of stimulus materials. A photograph appears in Figure 5-5 while a power supply diagram and a circuit diagram are appended in Appendix F and Appendix G respectively.

(c) A variable timer (a Heathkit Sine-Square Audio Generator used as in Figure 5-6) for variable inter-stimulus interval (ISI) desired. A schematic system block diagram is shown in Figure 5-7.

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[1] The construction of the control device owes to the discussion with and ingenuity of William Diachuk of Technical Services, University of Alberta. For this the writer is grateful.

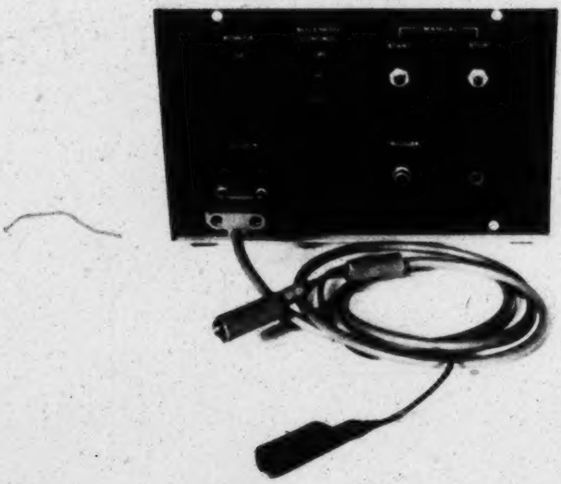


Figure 5-5. Photograph of control device specially designed, constructed for dichotic tape preparation.

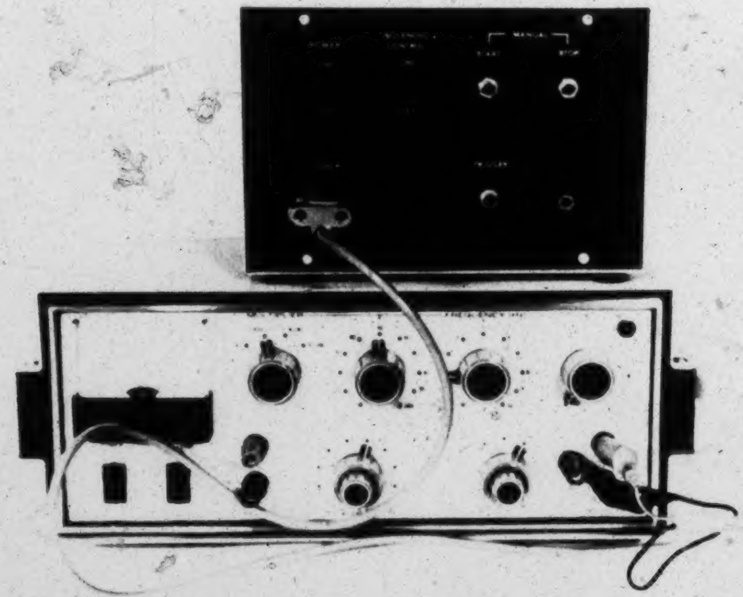
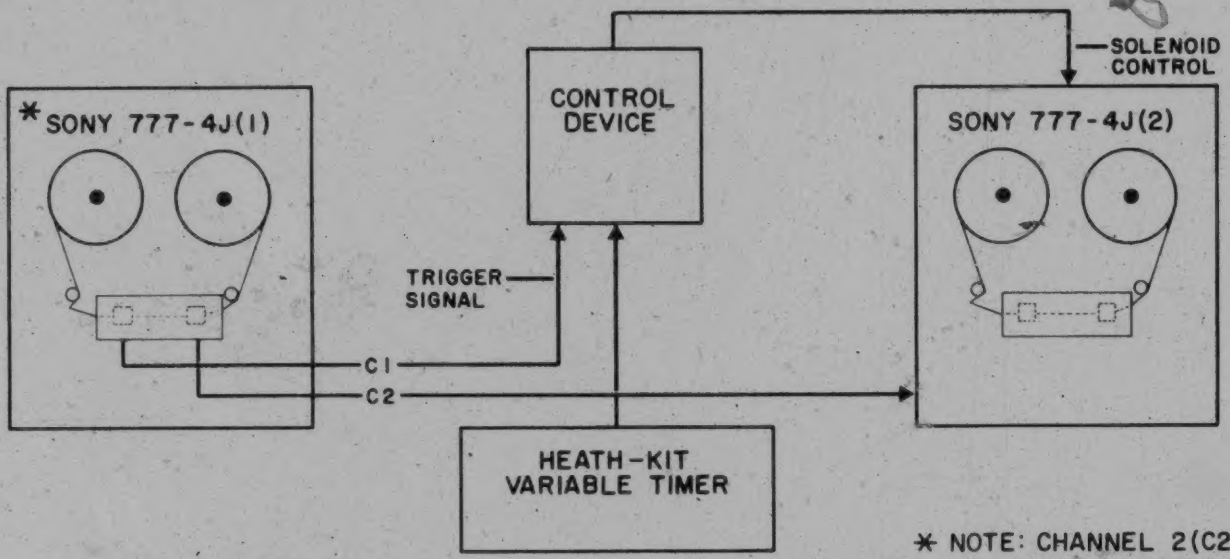


Figure 5-6. Photograph of Healthkit Sine-Square Audio-Generator with variable timer.


*SONY 777-4J(I)
CONTROL DEVICE
SOLENOID CONTROL
SONY 777-4J(2)
TRIGGER SIGNAL
CI
C2
HEATH-KIT VARIABLE TIMER

* NOTE: CHANNEL 2(C2) INPUT AMPLIFIER CONNECTION REMOVED FROM QUARTER-TRACK HEAD AND CONNECTED TO CHANNEL I(CI) HALF-TRACK HEAD. THUS C2 AMPLIFIER SERVES AS AN AMPLIFIER FOR A VOICE ACTIVATED SWITCH.

Figure 5-7. Systems block diagram for dichotic tape preparation.

A slight modification is made to the first tape recorder by removing its channel 2 input amplifier connection from the quarter-track head and connecting it to channel 1 half-track head. This enables the channel 2 amplifier to be used as an amplifier for a voice-activated switch. The solenoid control provides the necessary remote control with the capability of being activated by voice impulses and deactivated after the desired ISI (say, 1 second) from onset.

The operational sequence in the tape preparation is as follows:

(a) Preparation of tryout tapes by a trained speaker with due regard to intensity and duration as discussed in preceding sections.

(b) Recording of best samples from (a) above on to one track of a tape in such a way that the stimuli, say, digits, to be used sequentially in the same series will follow one from the other at a speed slower than that required in the final tape. Take as an example the 3-digit pair 5-9-8 in track 1 and 6-1-2 in track 2 as illustrated in Figure 5-4. If the rate of presentation or ISI is 1 second, all that is required for the master tape is recording at a constant rate separating the immediately adjoining digits in the sequence in the same track (5-9 or 9-8) greater than 1 second. Other than this steady pace, no precise ISI is needed at this stage. In practice, it is found 3-5 seconds separation time as monitored on a Hunter Decade Interval Timer is adequate. Also, the corresponding stimuli for track 2 (6-1-2 in the illustration) is recorded on the same track of the master tape. This can be done in two ways by either recording all the series (the set) for track 1 first and then the whole set with all the series for track 2 or by alternating each corresponding series between track 1 and track 2 (such as 5-9-8 followed by 6-1-2) before going back to the next series in track 1, then that in track 2. In practice, it is found this second method gives more efficacious results and reduces the time needed to rewind a greater tape length to ascertain, for example, the precise location of the series 6-1-2 to pair with 5-9-8 as would be the case with the first method.

(c) When the stimuli of matched intensity and duration within tolerance limits (350-500 msec. as found in practice and supported by previous research) are properly recorded as in (b) above on to a master tape, the latter is then set in the first tape recorder in readiness for the important and difficult task of re-recording of stimuli onto the two tracks of the second tape recorder to achieve onset synchrony. The interfacing of the two dual-channel recorder, the control device and the Heathkit timer is shown in greater detail in Figure 5-8. The complete instrumentation is shown in Figure 5-9. The playback tape recorder with matched earphones is that as shown in Figure 5-10.

The basic principle here is to use the voice impulses of the pre-recorded stimuli on the master tape to activate, via the control device interfaced with the Heathkit timer, and thence the solenoid control, the second tape recorder which will thus start slightly ahead of the actual digits to be recorded. As the operation goes, with the desired ISI set on the timer which is linked to the control device, the latter will "sense" the digits (say, 5-9-8) one at a time from the amplification on channel 1. This sensing will enable the second recorder to start, overcome inertia, pick up speed and attain steady state by the time the actual information arrives from the modified second playback head when the tape passes through. The duration for this to happen is

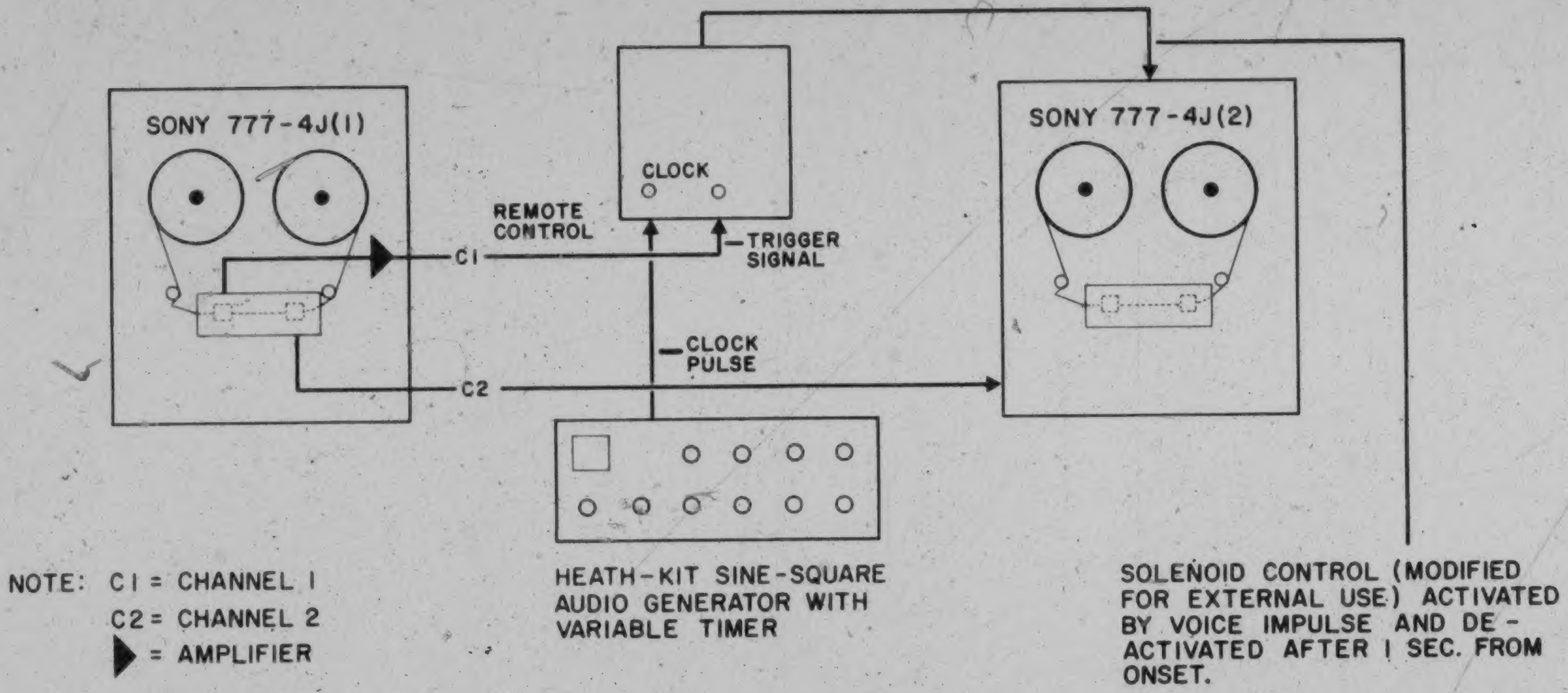

SONY 777-4J(1)
REMOTE CONTROL
C1
CLOCK
TRIGGER SIGNAL
CLOCK PULSE
C2
SONY 777-4J(2)
NOTE: C1 = CHANNEL 1
C2 = CHANNEL 2
▶ = AMPLIFIER
HEATH-KIT SINE-SQUARE AUDIO GENERATOR WITH VARIABLE TIMER
SOLENOID CONTROL (MODIFIED FOR EXTERNAL USE) ACTIVATED BY VOICE IMPULSE AND DE-ACTIVATED AFTER 1 SEC. FROM ONSET.

Figure 5-8. Expanded systems block diagram for dichotic tape preparation.

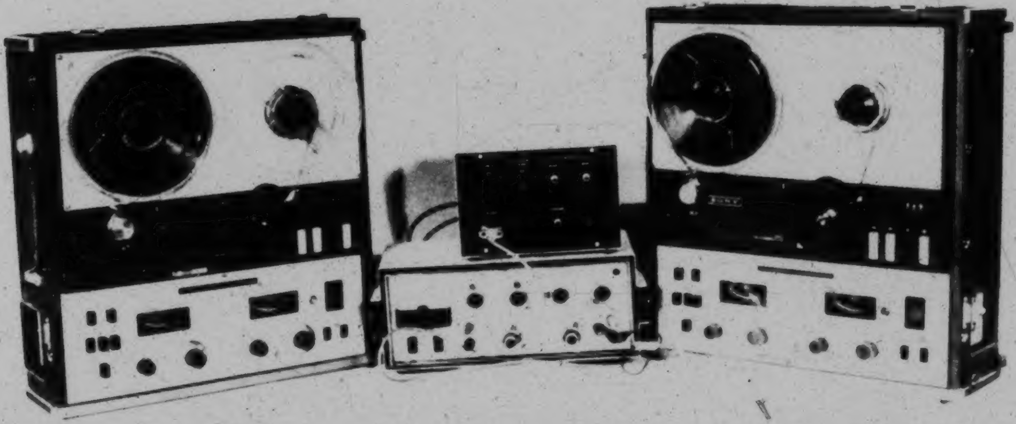


Figure 5-9. Photograph of complete instrumentation for dichotic tape preparation.

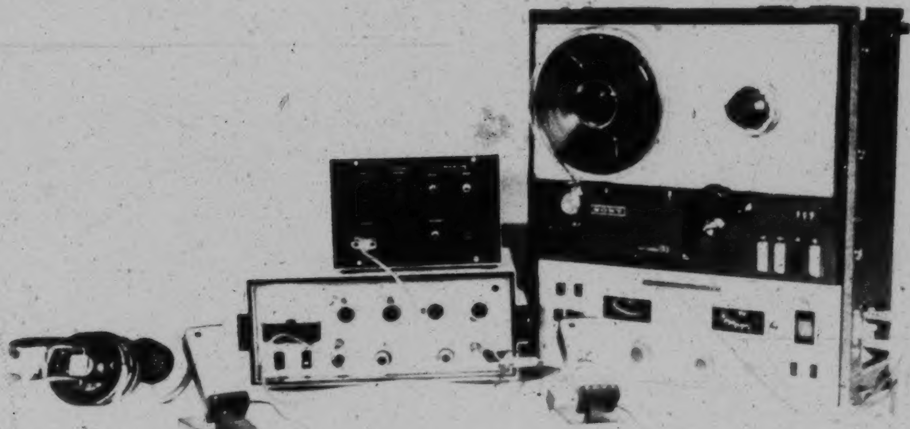


Figure 5-10. Photograph of playback tape recorder (Sony 777-4J) and earphones.

estimated at 180/200 msec. based on the measured distance of 1.35 inches between the record head and the modified playback head of the matched Sony 777-4J and with a tape speed of 7.5 IPS. This use of the voice activation and deactivation and the adjustable Heathkit timer for varying time intervals enables the digits to be recorded within the time duration specified (e.g., 2 pairs per second). When recording of each series (e.g., 5-9-8) on track 1 of the second tape recorder is completed as detailed, the second tape is wound back to specified marks on the tape and recorder deck for approximate alignment in readiness for synchrony. The same process is repeated for the recording of the corresponding series (6-1-2) on track 2 in synchrony with those digits already recorded on track 1. When this is accomplished for one series-pair $\left\{\begin{array}{l}5\text{-}9\text{-}8\\6\text{-}1\text{-}2\end{array}\right.$, the same procedure is repeated with the next series on track 1, which will be paired with its corresponding series on track 2. Preceding the test items sufficient tape length will be allowed for the insertion of instructions binaurally (same words for both tracks), which varies from 20 to 35 seconds while a response time (10 seconds found to be adequate with the present tasks) will be allowed between each series. This response time can be augmented by stopping the tape recorder manually when it is found the subject needs more time to make a verbal report. Following the completion of the final tape, synchrony can be tested on a polygraph machine (Hewlett-Packard 760 preamplifier with two-channel printout at varying rates from 0.25 mm./sec., 0.5 mm./sec., 1 mm./sec., 2.5 mm./sec., 10 mm./sec., 25 mm./sec., 50 mm./sec. to 100 mm./sec.). This essential step of checking for stimultaneity seems to have eluded most workers or is rarely reported. To the writer's knowledge verification has never been attempted on a polygraph machine. The two-channel printout provides easy to read and fine-grained comparisons of not only onset, but also offset and inter-stimulus interval.[1] As the purpose is the checking of onset synchrony and inter-stimulus interval rather than precise acoustic patterns, the method is relevant, practical and even superior to the use of oscillographs or spectrograms which are usually employed.

Following the procedure detailed in the preceding section the present writer laboured for some 60 days x 5 hours or approximately 300 hours in May, June, July of 1973 in the preparation of dichotic tapes including trying out different tapes and testing for synchrony of the four/five final tapes found most satisfactory. An early part of the time was used in testing the accuracy of the control device with an oscilloscope and in trying out the capabilities of the various equipments and the system as a whole. When this was done, a female speaker with a clear diction and considerable experience in making tape recordings was asked to record all the stimuli on clean, demagnetized 1.5 mil polyester tapes in a sound-proof room.[2] Technical apparatus was used to gauge intensity, duration of each digit/syllable and the appropriate ISI (3-5 seconds) for the tryout tapes. Some seven tapes from the best recordings were made and transcribed on to track 1 of seven different master tapes.

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[1] The writer is indebted to Glen Coward of Radio and Television Services, University of Alberta, for discussion of the concept and technical modification of the polygraph machine for the purpose.

[2] Appreciation is expressed to Mrs. Jean McIntyre of the Faculty of Education, University of Alberta for the use of the Speech Laboratory and Audiometric Area for the tape preparation.

One master tape relating to words with high and low meaning, two to different series of digits from one-digit pair (e.g., $\begin{matrix}4\\1\end{matrix}$) to five-digit pair (e.g., $\begin{matrix}8\text{-}1\text{-}3\text{-}4\text{-}2\\9\text{-}6\text{-}5\text{-}8\text{-}4\end{matrix}$) and one relating to a combination of three-element pair of digits and letters of the alphabet (e.g., $\begin{matrix}4\text{-}u\text{-}m\\a\text{-}1\text{-}7\end{matrix}$) served as "pretests" of both instrumentation and the dichotic stimuli themselves. These four completed tapes were not used subsequently for a number of reasons. The final tapes selected for the three Dichotic Listening Experiments 1, 2 and 3 (DL1, DL2, DL3) consisted of a tape with digits from 0 (zero) to 9 and two tapes with combination of digits and some letters of the alphabet. These stimulus materials will be described in the next chapter.

The succinct description above in no way shows the labour involved and at times the frustration engendered in an attempt to achieve precision and quality control. From personal experience, it can be stated with certainty that the writer's method of constructing dichotic tapes embodies the merits of most of the technical studies cited earlier, and also improves on them. The improvements include: the relative ease for the speaker to record the tryout and master tapes without great constraint of rigid adherence to presentation rates at that stage; the use of only two rather than three tape recorders; the obviating of the need for and the labour of splicing segments of tapes; the use of checks for acoustic quality of the stimuli at all stages of tape preparation. The greatest improvement of them all is the serendipitous use of the Hewlett-Packard polygraph to test for synchrony, which provides an easily decipherable acoustic printout to show time alignment. The ramification of this will be taken up in the following paragraphs.

To summarize the methodological aspects of dichotic tape preparation discussed in these two sections, it is pertinent to reflect on some practical difficulties which may have eluded many workers. It cannot be emphasized too strongly that considerable operational skills are required in making dichotic tapes, given the equipments described. At best the work is arduous and time-consuming. Many a time one has to erase a whole series and re-record the same to ensure duration for the series falls within reasonable time limits (e.g., less than 2.5 sec. for a 3-digit series). However, once well-versed with the system, the actual preparation of a 15-item tape with 3-digit pairs on the average should take about 8 hours. One difficulty relates to the limitations imposed by the mechanical aspect of even high-quality tape recorders, which in turn affect rates of presentation or inter-stimulus interval. It takes some time for a tape recorder to get started, pick up speech, attain the steady state required to make a recording without distorting the acoustic patterns. The time required is estimated to be around 180/200 msec. with the matched Sony 777-4J. Added to this is the duration needed to utter a syllable, which clusters round 350/400 msec. within a range of 350 to 500 msec. Thus for a spoken syllable or a digit to be recorded with the present system or for that matter the other systems outlined in the preceding section, the operation takes about 550/600 msec. This raises doubts as to the claims or the precise meaning of the often-mentioned importance of "two pairs per second." For example, Broadbent (1954, p. 194) states that "a ½ sec. interval was used between digits or pairs" and that "a pair of call signs arrived only every two seconds" (Broadbent, 1958, p. 211). The operation is not made any clearer by subsequent workers such as this: "onset of each simultaneous pair was half-sec. . . ." (Gray and Wedderburn, 1960); "one digit every two-thirds of a second" (Inglis and Caird, 1963); "2 signals/ear/sec." (Moray, 1960); ". . . two pairs per second" (Urbano and Scott, 1969); "pairs were presented at the rate of 2/sec." (Zurif and Carson, 1970). From empirical findings of some 550/600 msec. needed for recording a syllable the only acceptable explanation of "two pairs per second" is that of "the interval between the beginning of one digit and that of the next was 1 sec." (Broadbent and Gregory, 1961, p. 106). This includes the stimulus duration and the inter-stimulus interval (ISI) shown in Figure 5-4.

The mention of "beginning of one digit" brings one back to the questions raised early in Section 5.5 about the onset and synchrony of stimuli. This is rarely discussed in the psychological literature per se. The definition adopted for the present study is that of Studdert-Kennedy and Shankweiler (1970) who explain onset on an oscillographic record as the first excursion above noise level that is sustained and followed by clear periodicity. An illustration is given in Figure 5-11 of the sample oscilloscope records of two pairs of digits "1" and "3" and "2" and "4" respectively. In actual practice, the instant of "onset" for a monosyllable is generally difficult to determine since the beginning of phonation is not marked by a single event having a conspicuous acoustic correlate which is easily displayed on a cathode ray tube of a two-channel storage oscilloscope. This difficulty is minimized by the use of test materials which begin with plosive consonants. By so doing, the point where the speech signal departs from ambient background noise to a fast

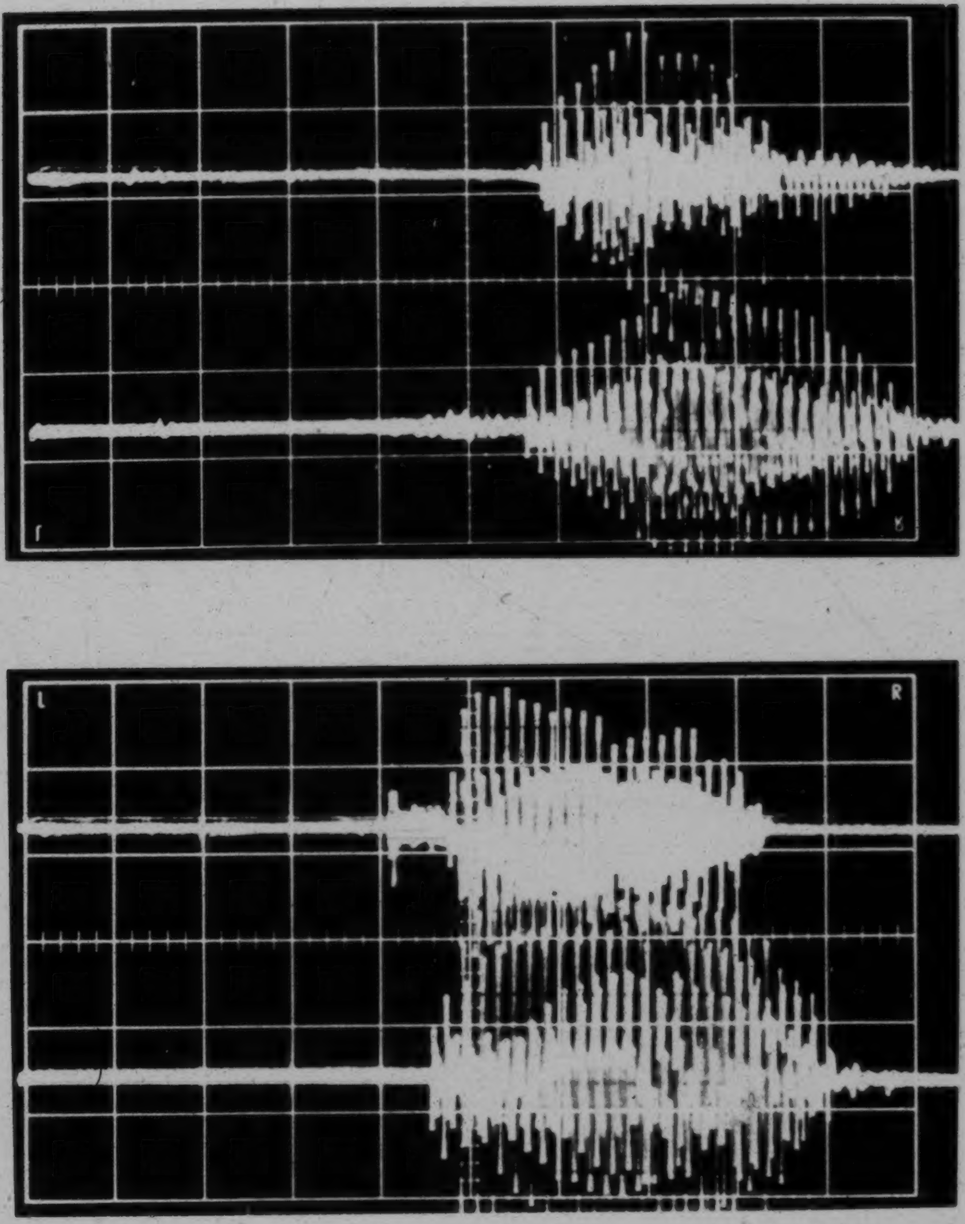


Figure 5-11. Sample oscillographic records displaying acoustic patterns of pairs of syllables in temporal alignment. Top record shows pair of digits "1", "3" in each channel from top down. Bottom record shows pair of digits "2", "4" in each channel in the same order. Each division represents a time duration of 50 msec.

rising aperiodic excitation of voicing can be agreed upon consistently. The departure from ambient background noise served as our operationally defined point of "onset." Again, one has to turn to research in speech perception that pinpoints some of the methodological problems that have plagued other workers for some years. The recent finding by Berlin et al (1973) mentioned earlier of differential perception affected by 30-60 msec. lag effect further highlights the problems related to onset synchrony. Of the three final tapes prepared and tested on the two channels of the polygraph the average onset synchrony or dys-synchrony is well under the 30 msec. threshold for each tape. Sample polygraph tracings of dichotic digits originally recorded at 25 mm. per second are shown in Figure 5-12. The tracings record faithfully and precisely the synchrony, inter-stimulus intervals and duration of dichotic digit sequences. A further improvement in onset synchrony was effected through the assistance of Dr. A. J. Rozyspal and Allan Oppertauser of the Linguistics Department, University of Alberta. The onset synchrony was brought within 5 msec. difference and the adjusted final versions formed the test materials for the three dichotic experiments.

In addition to defining and overcoming difficulties related to rates of presentation and onset synchrony the role of the acoustic qualities of the phonemes affecting perception is beginning to be realized in psychological literature. This has a direct bearing on the instrumentation used. During the preparation of tapes it was found that the control device worked well with pure tones which would activate the second tape recorder and deactivate it precisely with the desired ISI just as designed. But when speech sounds were used it was found that

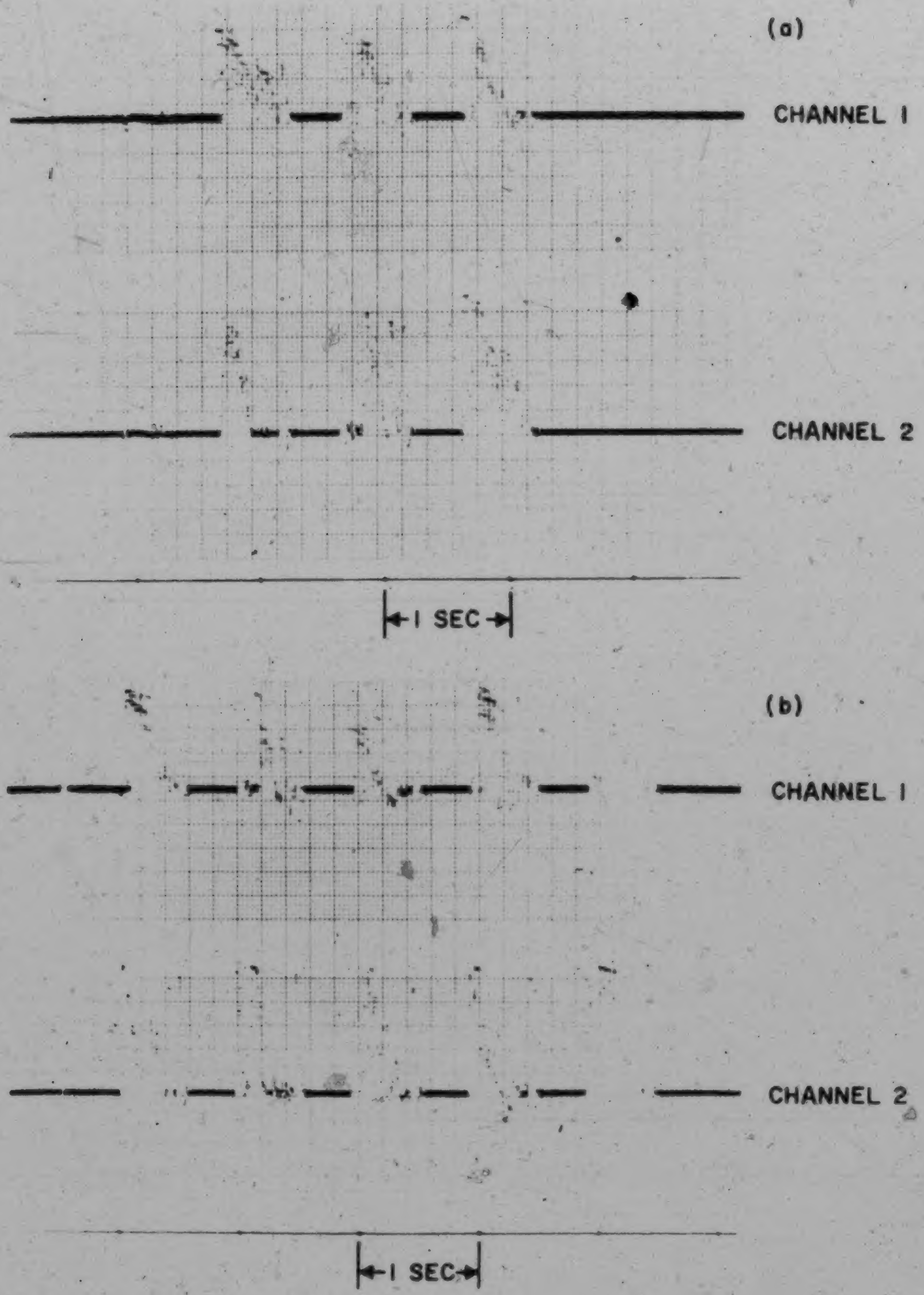


Figure 5-12. Sample polygraph tracings on a reduced scale (original printout on 25 mm/sec) of dichotic digits to show synchrony, interstimulus interval and duration of digit sequences. Tracings in top record show 9-3-1 in channel 1 and 8-7-9 in channel 2 (from top down). Tracings in bottom record shows 2-7-4-2-3 and 5-6-1-4-2 in channel 1 and channel 2 respectively.

sometimes sound streams in different phonemic environments and with different signal-to-noise ratio might trigger off for recording the second recorder ahead of the stipulated time, thus throwing synchrony into slight disarray. This could happen even with heavy breathing when the speaker recorded the tryout digits too close to the microphone or when the intensity was too high. This could also happen with decreased signal-to-noise ratio as was found with a compressed tape compressed on a BA-43/45 AGC Program Amplifier Unit 11455. This unexpected "filtering" is double-edged. On the one hand, it alerts the researcher to the need to carefully control intensity and other acoustic qualities prior to attempting step (c) outlined at the beginning of this section. The unexpected filtering also points to the vulnerability of an electronic/mechanical system short of computer control in response to complex speech codes. As demonstrated with discrete pure tones, were the mostly monosyllabic stimuli (speech segments) strictly linear the instrumentation would work perfectly to specification. As it is and as discussed in Section 2.6.2 and elsewhere, speech is also multi-dimensional. The experimentation with the dichotic system thus provides some indirect evidence for this. Figures 5-13 and 5-14 reproduce the acoustic patterns as recorded on an oscillograph (original recording at 50 mm./sec. and expanded 12 times) of all the digits and the letters of the alphabet used in the three dichotic experiments. The digits and 10 letters of the alphabet were freely spoken and no temporal alignment was intended for each pair as shown. The tracings give some idea of the complexity, and variable patterns of different speech signals. As discussed earlier the complexities of speech code perception are well pointed out in an

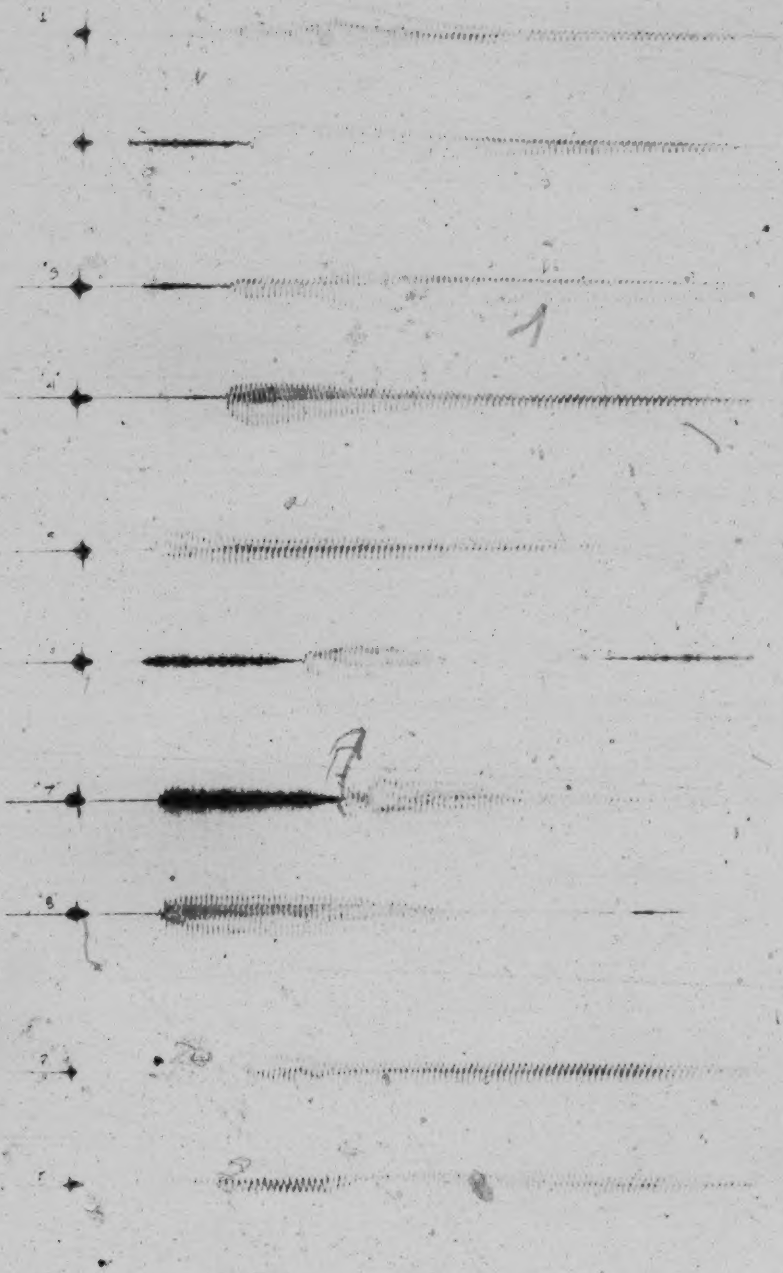


Figure 5-13. Specimen oscillographic records of individual digits from 1 through 9 to 0 (zero) in that order from top down. Taken originally at 50 mm/sec and expanded 12 times, the digits are freely spoken and no temporal alignment for each pair is intended.

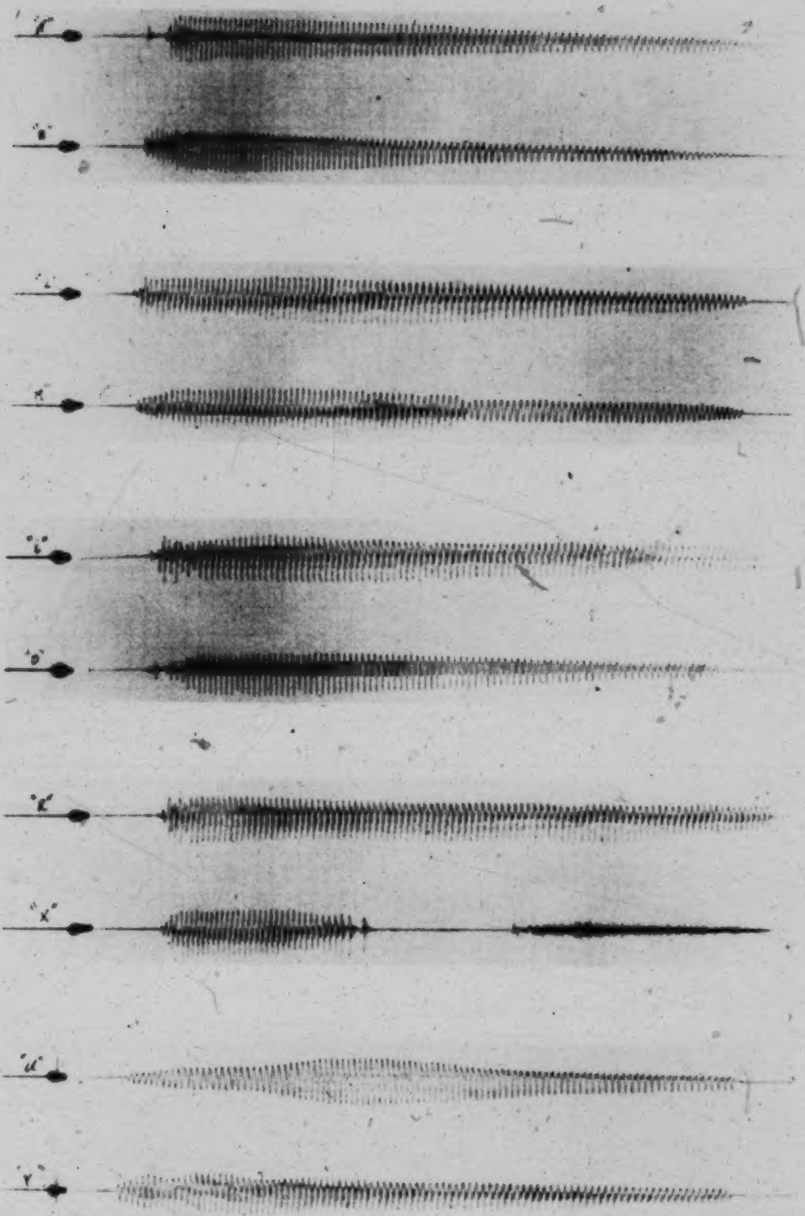


Figure 5-14. Specimen oscillographic records of individual letters of A, E, L, M, I, O, R, X, U, Y in that order from top down. Taken originally at 50 mm/sec and expanded 12 times, the letters are freely spoken and no temporal alignment for each pair is intended.

important paper by Liberman, Cooper, Shankweiler and Studdert-Kennedy (1967) while the differential effects of consonants and vowels on lateralization are brought out by Studdert-Kennedy and Shankweiler (1970). It is with the awareness of these speech perception findings that one should use dichotic listening techniques even though the tasks may not be directly related to the finer aspects of psychoacoustics.

5.6 Review

This chapter begins by reviewing the previous three chapters dealing with the theoretical consideration of hemispheric specialization and information-processing in the context of reading dysfunction. The search for the link between the neuropsychological and psychological aspects of serial order and simultaneous-successive syntheses leads to the dichotic listening paradigm. Its basic theoretical underpinnings--Broadbent's filter theory and the different cerebral asymmetry models of Inglis (order-effect model) with its variant differential storage model, Kimura's perceptual model and Bryden's perceptual-threshold model--are reviewed. Subsequent experiments will attempt to assess the contribution of memorial and perceptual processes to lateralization as shown in dichotic listening tasks. These tasks have found a number of applications dealing with brain pathology, handedness, selective attention and with different groups of exceptional children. Recent work in the speech perception area particularly from the Haskins Laboratories has shown dichotic verbal tasks to be highly complex. Stop consonants and vowels are differentially perceived, so also the articulatory features of voicing and place of phonation with the former; and the effect of lag time on perception. These important analytic findings, often eluding workers in cognate disciplines, have alerted the present investigator to the need to critically examine existing techniques of dichotic tape preparation and related technical problems. The quest has resulted in the devising of a much improved instrumentation together with a simple but effective quality-control for experimentation. An assessment is made of the efficacy of the instrumentation and methods of preparation of dichotic stimulus materials. Attention is again drawn to the complex speech codes relevant to the dichotic paradigm.

CHAPTER 6

EXPERIMENTAL AND CORRELATIONAL STUDIES--FORMULATIONS, SAMPLE AND TASKS

> Contrariwise, if it was so, it might be; and if it
> were so; it would be; and if it isn't, it ain't.
> That's logic.
>
> Tweedledee in *Alice in the Looking-Glass*

6.1 Formulations and Hypotheses

Unlike Tweedledee, the researcher may not be forgiven for the logically illogical or the illogically logical. From the theorizing in previous chapters, there are two logical strands in the present investigation. One pertains to the main formulation that reading dysfunction may be related to a lag in the maturation of the left hemisphere and a corresponding lag in the functional specialization of language (Chapter 3 and Chapter 4). This formulation is testable via the dichotic listening paradigm (Chapter 5). The second main formulation pertains to spatial-temporal coordinates underpinning beginning reading or reading disability, verifiable through some "non-reading" tasks known to be loaded on the simultaneous-successive matrix. These two main formulations lead to two parallel but integrated studies woven within the fabric of hemispheric specialization with the dichotic listening tasks and spatial-temporal tasks providing the threads. The three main dichotic experiments in the tradition of experimental studies all aim at studying processes relating to functional cerebral development with assessment of relative contributions of perceptual and memorial processes. The second group of studies is largely correlational and is designed to examine the structure underlying some cognitive/perceptual tasks so essential to beginning reading. Once again, the two main studies are forged together by a discussion of the strategies involved in information-processing amongst young children. Attention should be re-directed to the flow-chart in Figure 1-1 (Chapter 1) which gives the main "programme" together with the "subroutines" of the two major formulations. The sequential steps of the theoretical framework, experimental paradigms and operations are also given. In this and the following chapters the formulations and results will be presented and discussed mainly as two parallel but related studies with interlocking pointers clearly visible along the way. A synthesis in the chapter on "General Discussions of the Investigation" (Chapter 10) will provide further "converging operation" to bring the studies together.

6.1.1 Study I--Three Dichotic Listening Experiments

Following the main formulation in Study I of hemispheric specialization and the lateralization of language functions these broad questions will be raised. Is there an ear difference in perception of dichotic stimuli of digits and letters of the alphabet amongst a group of severely disabled readers? Is there an ear difference between these children as a group and an "equivalent" one of non-disabled readers? If there is an inter-group lateralization difference, could such a difference be due to differential methods of scoring dichotic tasks? Could the ear effect be due to differential memorial and perceptual processes and could such be ascertained from the experiments? Is there any interaction effect between or among the factors of: group (disabled and non-disabled readers), ear-order (left- and right-ear effect) and series length of stimuli (2-, 3- and 4- digit pairs)? Or is the differential ear effect a function of different series lengths? If the latter is assumed to have an effect, then holding series lengths constant and instructing the children to use different strategies to report the dichotic stimuli they hear, perhaps the differential ear effect would be minimized. Or does it? Do these children in fact process dichotic stimuli differentially in relation to strategies of "sides" (left or right ears) and of "types" (by digits and letters of the alphabet)? Does the nature of the stimuli (digits and letters of the alphabet) make a difference in any group differentiation?

It may be pointed out some of these questions may have been raised singly with other groups of exceptional children. Where the present study differs from previous ones is that an attempt is made to view these related issues in concert rather than in isolation so as to provide a useful heuristic framework. Take as an example, dichotic listening experiments with disabled readers have mostly related to the ubiquitous question of handedness (see Chapter 5, Section 5.3). As outlined in Section 3.5 findings pertaining to cerebral lateralization, handedness and speech brainedness and reading have not been less unequivocal. Thus a clearer delineation of differential ear effects will help clarify some of the more molecular issues. Moreover, the much improved and refined stimulus materials together with "quality control" showing margins of errors of the dichotic stimuli all contribute to the precision of the experiments and hence better understanding. The main questions posed have led to the following hypotheses:

Hypothesis 1

It is hypothesized that children with specific reading disability (Experimental Group) will perform less well on dichotic listening tasks when compared with a group of non-disabled readers (Control Group). Hypothesis 1 can be broken down into:

1a. Both the Experimental Group and the Control Group will show an overall right-ear effect.

1b. The Control Group will show significantly higher ear scores than the Experimental Group.

1c. The difference found in (1a) and (1b) will be maintained with two different methods of scoring: ear order scoring and attempted ear order scoring (methods of scoring explained in subsequent sections).

Hypothesis 2

It is hypothesized that the ear difference suggested above could be attributed to differential perceptual and memorial processes.

The aim is to assess the relative importance of cerebral asymmetry (the Kumura-Bryden model) and memory (the Broadbent model) in the processing of dichotic stimuli (see Chapter 5, Section 5.2).

Hypothesis 3

In comparing the dichotic performance of (a) the two groups (Experimental and Control), (b) left and right ears and (c) series lengths (2-digit, 3-digit, and 4-digit pairs), it is hypothesized that there will be a significant main effect due to each of the three factors.

In other words, the Control Group will excel the Experimental Group; the right half-span betters the left half-span and that different series lengths affect dichotic performance.

Hypothesis 4

It is hypothesized that in serial scoring of dichotic stimuli the Control Group will be more efficient than the Experimental Group in using pre-instructed strategies as shown in the greater difference between sides (ears) and types (digits and letters of the alphabet) scores. These results may not be as clear-cut in free scoring.

Hypothesis 5

Related to the immediately foregoing it is hypothesized that the Control Group will perform better than the Experimental Group irrespective of the types of stimuli used and that the difference between the stimuli (digits and letters) is not significant. These results are expected to maintain with both serial and free scoring.

Empirical evidence derived from these related hypotheses will go in some way towards clarifying the postulate of functional cerebral development in children with specific reading disability. The differential use of strategies in dichotic tasks leads to Study II.

6.1.2 Study II--Two Correlational Studies of Simultaneous-Successive Matrix

Previous component studies of Das (1972a, 1972b, 1973a, 1973b) have shown, with some variations, the realities of simultaneous-successive syntheses with different IQ groups (mildly mentally retarded and non-retarded); with young and old school children (six- and ten-year olds); with different socio-economic groups (low and high SES) and with different ethnic and cultural groups (Canadian native Indians, Canadian white children and high caste children from India). The fairly consistent findings raise some interesting questions when disabled readers are studied within the same paradigm. Do similar patterns obtain with a group of disabled and an equivalent group of non-disabled readers? Is there an inter-group difference in the patterns? Could the constructs derived be attributed to a particular method of analysis or could invariant results still obtain from more than one method, assuming the underlying models are applicable? How stable are the patterns across the two groups given the constraints of sample size? Are the patterns stimuli-specific or would they still maintain with slight variations in the tasks used? Are the constructs modality-specific relating as the tasks probably do mostly to the visual and auditory channels or are the constructs generalizable to the spatial-temporal dimension rather than to the modalities? What exactly is the nature of simultaneous-successive syntheses as proposed by Luria (1966a, 1966b, 1973) and operationalized by Das (see Chapter 4)? Are the simultaneous and successive components parallel rather than hierarchical but inter-dependent as claimed? Would it be more meaningful to view the constructs as in at least an interchangeable two-dimensional matrix? It is to these a priori questions that the correlational inquiry in Study II is addressed.

Hypothesis 6

It is hypothesized that the component/factor analyses of tasks predominantly from the Luria/Las battery will demonstrate the presence of simultaneous-successive dimensions.

It is further hypothesized that the dichotic listening sides and types tests will load on the successive dimension and that the simultaneous-successive patterns are method-independent as attested by different models and methods of analysis.

6.2 Sample and Methods

Briefly stated, the sample consisted of an Experimental Group of 58 boys (mean CA=111.069 months, mean Lorge-Thorndike non-verbal IQ=102.448) severely disabled in reading and a Control Group of 58 boys who were above-average readers (mean CA=110.931 months, mean Lorge-Thorndike non-verbal IQ=107.569). The groups were equated on age, sex and ability level. These two groups were given 3 dichotic listening experiments and some tests of cognitive abilities including the Luria-Das battery of tests pertaining to simultaneous-successive information-processing. The several stages of the inquiry are presented in Figure 1-1.

All the field work was conducted by the present writer in situ in 16 different schools from October, 1973 to mid-January, 1974. In all, 55 working days totalling in excess of 275 man/hours were spent in the schools. The general pattern of experimentation in each school was to administer the tasks in about three blocks. In block 1 the Figure Copying Test and

Raven's Coloured Progressive Matrices, in that order, were given to the children in both the Experimental and Control Groups. This was followed by the Visual Short-Term Memory Test given to each of the groups separately and then the Memory-for-Designs Test to the children individually. In blocks 2 and 3 the three dichotic listening tasks were interspersed with the remaining four simultaneous-successive tasks (Auditory-Visual Coding, Auditory Serial Recall, ITPA Visual Memory, ITPA Auditory Memory). Dichotic Listening Experiment 1 (DL1) always preceded Dichotic Experiments 2 (DL2) and 3 (DL3), while the order of presentation for the latter two was randomized. Generally, in each school three separate visits were required for the entire tests and experiments. Within this administrative framework, care was taken to ensure equitable testing conditions and to minimize fatigue. The experiments and tasks were well received by the children. The procedures of experimentation, general and specific methodological problems pertaining to sampling, and descriptions and comments in regard to the dichotic and simultaneous-successive tasks are detailed in the following sections.

6.2.1 General Considerations of Sampling

Mention has been made in Section 2.6.4 of methodological problems in reading research, particularly those relating to the stages of reading reached by the children and those relating to sampling. In the selection of children for the studies cognizance is taken of the theoretical implications raised by Applebee (1971) and of the practical difficulties (discussed in Section 2.6.1) encountered by such recent researchers as Doehring (1968), Naidoo (1972), Owen, Adams, Forrest, Stolz, and Fisher (1971) in their work with disabled readers. In the present investigation the selection of children would be according to these criteria:

(a) To strike a balance between what has been called educational and clinical models of sampling (though the two overlap) a group of dyslexic-rich children will be selected. These children will accord with those operationally defined as children with specific reading disability (see Section 2.3 Terms and Concepts). The definition by Eisenberg (1966) of children with average intelligence, culturally adequately homes, intact senses and freedom from gross emotional problems and neurological defects but with reading being the main deficiency seems reasonable. As will be seen, generally accepted definitions as this one bring with them certain problems and may need critical re-appraisal.

(b) In the section dealing with the heterogeneity of disabled readers (Section 2.4) the differential sex ratio of more boys to girls with reading disability has been pointed out and the perplexing pros and cons for this difference have been discussed. In order to provide for convergent operations, only boys within a specified age range will be selected for the investigation. While this may suffer from certain narrowness (in the developmental sense) with its concomitant statistical drawbacks of restriction in range, the boys-only age-restricted sample makes for more homogeneous grouping and safer generalizations, given the relatively small sample size an individual researcher is obliged to contend with (Doehring, 1968). Moreover, the drawback of restriction in range can be minimized in two ways: (a) by studying children at the stage of fairly rapid and yet stable development in respect of the differential abilities sampled and (b) by providing a span of 16 to 18 calendar months within the narrow age range specified. Thus the children selected will more likely be in grade 3 or grade 4 in elementary schools. Also, young disabled readers at about age 9 are less likely to have their reading difficulties contaminated with or compounded by emotional problems, as would be with older dyslexics. The belief that emotional problems cause reading difficulties needs to be interpreted with caution as the truism that correlation does not necessarily mean causality is all too well known. Any correlation should be related to the stages of the reading process, the severity of difficulties, the age and motivational level of the children affected. With younger disabled readers it is very likely that emotional overlays are secondary to the reading problems. If cause-and-effect is to be inferred at all (which is not warranted), it is very possible that far from emotional problems causing reading difficulties, the direction may work in reverse at the initial stage of reading. For the above reasons it is felt that dyslexic-rich boys aged about 9 who will normally be in grade 4 will circumvent some of the methodological problems and should be selected for study.

The basic approach adopted is one of two-group sampling of children. Earlier in the chapter mention is made of a reading-disabled group and an equivalent group of non-disabled readers. This equivalent group design is analogous to the matching procedure often used in studies of the mentally retarded and brings with it thorny problems--both conceptual and statistical. Conceptual because it is difficult to define exactly the parameters within which matching should be done. With the usual match for intelligence one may legitimately ask on what test or tests and whether the subtests of the test or tests, (as in the case of the WISC) are equated? Having matched for IQ one may ask if such variables as attention, hyper- or hypo-activity, motivation, SES and EEG readings are not irrelevant? Statistical, as there are pitfalls in matching such as the inadvertent choice of extreme groups to achieve apparent equivalence and regression effects (Hopkins, 1969; Stanley, 1967; Thorndike, 1963). Unlike studies in mental retardation where both MA and CA matching is germane for different reasons, MA match to compare rate of learning or development and CA match to compare levels (Baumeister, 1967; Denny, 1964; Haywood, 1970). Some of the criticisms of equivalent groups do not apply with the same force in inquiries into reading dysfunction. In particular, the danger of matching leading to regression effects is minimized in the present investigation as the purpose is not one of prediction of reading proficiency from a number of independent variables. The purpose is to examine certain conditions affecting lateralization and to some extent information-processing in a group operationally defined according to some a priori criteria (Section 2.3 and this section). This group is compared with or contrasted with an equivalent group of the same sex, similar ages and ability level but differing only in (as is known or measurable) reading performance. Rather than viewing the operation as one of matching with its attendant pitfalls, one may phrase the overall research postulate in a more positive way. Given a group of nine-year-old boys with specific reading disability, how do they perform in some perceptual-memorial and cognitive tasks vis-a-vis a similar group of non-disabled readers? Do the groups use similar strategies with varying conditions and show similar structures (Figure 1-1) in processing information which is basic to the reading process? When viewed this way, the two-group approach affords logical as well as much greater statistical power in the interpretation of results. In turning thus from the Scylla of conceptual and statistical exactitude to the Charybdis of the experimental and administrative practicality, one has to steer a course which is theoretically sound, statistically defensible and administratively convenient, as Sir Cyril Burt aptly observed many years ago in the context of the English 11 plus examination.

6.2.2 Specific Sample Studied and Comments

In the actual selection of the Experimental group of children for investigation the preceding general considerations were operationalized in these specific terms:

(a) Children with specific reading disability and in particular only dyslexic-rich boys would be included.

(b) These boys would have dates of birth between February, 1965 and August, 1963 with a chronological age (CA) ranging from 8 years 7 months (8-7) to 10 years 1 month (10-1) or a span of 18 calendar months as on 1st October, 1973 when the studies would begin.

(c) In keeping with accepted operational definition the reading disabled boys so selected would be average or above average in ability level and in any case would have a measured IQ not less than 85 in order to eliminate any confounding with mental retardation.

(d) Added to the above constraints, the reading disabled boys would be free from gross emotional problems and from known visual and auditory defects as attested from school records and teachers' reports.

Before detailing sampling procedure in subsequent paragraphs, a word about the sources from which the sample would be drawn is in order. In the public school system of the city where the investigation was carried out (Edmonton, Alberta, Canada) children with specific reading disability as operationally defined in Section 2.3 are integrated in what are called adaptation classes in various public schools. These children whose main problem is one of severe reading difficulties but who otherwise are free from intellectual, emotional, visual and auditory disabilities are primarily nominated for these classes by their respective teachers. From a criterion of at least two grades and more of "reading retardation" based on cumulative testing with a battery of general ability, reading and diagnostic tests, parental interviews and observations of these children in situ plus medical examinations including audiometric testing where appropriate, recommendations for adaptation class placements are made. These are almost invariably accepted by the parents as in the best interest of the children. Classes with up to 10 children each are sufficiently small to allow for individualized teaching and flexible grouping and programming make for integration of these children with their peers in regular classrooms. Moreover, the provision of separate opportunity classes for the mildly mentally retarded and classes for the emotionally maladjusted in the same progressive school system minimizes the danger of the group studied being contaminated with these extraneous variables. For the 1973-74 school year there were 34 junior adaptation classes in various schools with a total enrolment of approximately 340 children, 12 senior adaptation classes with an enrolment of approximately 120 students and 35 pre-vocational classes with approximately 35 x 15 students or 525 students. Children in the junior adaptation classes would be aged 6 to 11+ and would "graduate" into senior adaptation classes on reaching 12+ from where they move to pre-vocational classes at about age 13 years 6 months or older. In practice children eligible for the adaptation classes would not be considered for placement until they are near 8 years of age or well in grade 2 and the ratio of boys to girls is in excess of 2 to 1. The system of different levels of adaptation classes from junior high through senior to pre-vocational is designed to provide maximum help to individual children.

With this understanding of adaptation classes, the actual selection of children for the investigation began from about the middle of August, 1973 to the third week of September, 1973 by several stages (schedule of administrative arrangement in Appendix A). In Stage I the present writer sought and obtained permission to read through the often voluminous files on the boys in junior adaptation classes to familiarize himself generally with the nature of the learning problems of these children. Next, the names of all those boys with dates of birth, general ability level and other constraints as detailed earlier in this section were found and the number totalled 70. From this population with a specified age range and ability level a random selection was made of

60 boys for the study. The magical number of 60 was arbitrary as being manageable in respect of predominantly individual tasks to be performed (estimated at 2 ¼ hours per child) and as being statistically defensible in relating sample size to the number of 8 to 10 variables in the correlational studies. This method of incidental sampling within the larger "population" would also reduce any possible bias. From this pool of 60 children detailed study was made of their school achievement, diagnostic findings and family history as recorded in their files and cumulative records. This search at Stage I took approximately three weeks.

Stage II consisted in consultation with all the principals and teachers concerned to obtain their advice on the sample, sampling procedure and to inform them of the nature of the project. In situ observation of some children in their classrooms was also carried out. On the suggestion of the schools 2 boys had to be eliminated from the list of 60 for the Experimental Group. The final selection for the group thus consisted of 58 boys with specific reading disability spread over 16 different schools with a minimum of three to a maximum of five boys in each school. These children had all been screened for normal hearing by qualified speech clinicians in the public school system (25 dB ± ISO, o.25 K to 8K Hz). The consultation with individual schools provided further check to ensure the 58 boys in the Experimental Group did conform to the stipulated requirements of age, sex, ability and reading levels.

The basic principle in the selection of the Control Group (Group CO) was one of equivalence in respect of age, sex and general ability level with reading performance being the only known variable differentiating the two groups. The procedure of selection, which began in mid-September, was as follows. First, each of the 16 schools enrolling the 58 disabled readers was asked to select from the same grade (grade 4 mostly) all the other boys with dates of birth falling between February, 1965 and August, 1963--the same period as the boys in Group EX. Next, this larger group of boys aged 8-7 to 10-1 (as on 1st October, 1973) was divided into two groups according to whether the boys were reading at a below average or above average level as estimated by the teachers and confirmed from standardized test results. The below average group was defined as those scoring less than 50th percentile on word reading and paragraph comprehension in an efficient reading test (usually but not always the Gates-MacGinitie). These children were not sufficiently "retarded" in their reading performance to warrant placement in adaptation classes. The above average (AA) reading group consisted of those boys performing above the 50th percentile in both word recognition and paragraph comprehension, again usually on the Gates-MacGinitie. Care was taken to ensure that these AA boys were free from gross emotional problems, visual and auditory defects. From their above average reading groups individual schools further selected at random from those with general ability estimated as average the same number of AA boys as there were Group EX boys in their respective schools. Thus in each of the 16 schools there was the same number of above average (in reading) boys (ranging from 3 to a maximum of 5) as there were disabled readers. The total number of 58 AA boys so selected formed the Control Group (Group CO). The reason for asking teachers and principals to select the Control Group was that teachers know their students best and it has been shown that teachers' estimates of children's ability and achievement conform quite well with standardized test results. Also, by confining attention to only boys in one grade the task of estimation was made easier and more consistent. In actual practice, it was known that in not a few cases results of group ability tests and reading tests as available in cumulative school records were used as yardsticks for confirmation of teachers' estimates.

In selecting and equating the Experimental Group and the Control Group two variables posed some op[illegible]nal problems. One was the line or rather the zone of demarcation of reading performance and the other was the comparability in ability levels. On reading performance the boys in Group CO (except for 4 children transferred from other provinces) were all tested in the basic subjects of reading, spelling and arithmetic within a six-month period of the beginning of the present investigation as part of the regular system-wide group testing programme conducted in late April and May. Children in Group EX, on the other hand, had been assessed individually on a cumulative basis with different instruments over the previous 18 or more months. Thus at the outset the investigator was faced with the decision of two alternatives, if a quantitative comparison of the two groups was needed. One was to administer to all members of the two groups a common reading test to further gauge their reading performance. The other was to accept recent test results available from school record cards as measures of relative reading performance.

The first alternative was not considered desirable or in the interest of the children, particularly for those in the Experimental Group. There is also the methodological problem of finding a test or tests which can assess the differential reading abilities of the two disparate (in reading skills) groups. With the Control Group at the relatively "advanced" stage of reading and the Experimental Group at the initial stage of decoding (see Section 2.6.4 and Smith, 1971) the questions arise as to which component or components of reading skills--word recognition, paragraph comprehension whether measured via "classical" or cloze tests--should be taken as the common yardstick. There is the further question of not adding to the considerable time taken by the studies (at about 2 ¼ hours per child). Moreover, motivational factors must be considered as Group EX children have invariably developed, as the result of cumulatively testing, an inveterate test-phobia towards achievement tests, if not test-wiseness. For all these reasons it was decided not to impose a further reading test on the children just for the sake of obtaining a score which may or may not reflect with precision the breadth and depth of reading skills in the two groups.

This decision thus left the investigator with the second alternative of using reading test results available in school records as being the more acceptable. With the Control Group Gates-MacGinitie results (except for 4 children) were recorded in percentiles and were not amenable to statistical treatment. Suffices it to say that inspection of the profiles in both verbal and comprehension sections showed that the 54 children performed round the 75th percentile. With Group EX the "best" and invariably the most recent (to within 3 months or less of present investigation) reading results were used and these were from two well-tried reading tests--the Neale Reading Test and Schonell's Word Recognition Test.

On the Neale Reading Accuracy Test the mean for the group was 85.78 months (approximately 7 years 2 months) with a standard deviation of 5.7 months while the mean Neale Reading Comprehension score for the group was 85.17 months or approximately 7 years 1 month with a standard deviation of 5.62 months. On the Schonell RIA Test (Word Recognition), however, the average reading age for the group was only grade 1.3. On the surface the Neale accuracy and comprehension scores (which have been shown to be highly correlated) placed the group as reading at the very beginning of grade 2 level when they should have been at the grade 4 level while the Schonell test only put the group at the beginning grade 1 reading level. As mentioned, the "best" of the Neale scores used after 2 or 3 testing in the course of 12 or 18 months with the same instrument with "gains" evident from the records might be due in a small measure to practice effects, even though the Neale has been known to be relatively free from this. Thus the Neale results might be slightly inflated. More than the Neale, the Schonell Word Recognition Test has been found (with the English 11 plus examination and the present writer's clinical experience) to be singularly resistent to both coaching and practice. Thus it was felt that the Neale reading age of approximately 7 years or grade 2 should be taken as the upper limit of performance of Group EX and that the more stable Schonell reading age of 6.3 or early grade 1 more correctly reflected the reading level of these 58 children at the time of experimentation. This assessment was generally confirmed by the teachers and substantiated by in situ observation of the often erratic oral reading of the individuals. The figures were thus accepted as entirely defensible statistical description, albeit ad hoc, of the two groups under investigation.

The other operational problem mentioned earlier relates to the comparison of ability levels of the Experimental Group and the Control Group. Careful re-reading of the literature on group studies of disabled readers does not offer much insight. Some of the recent work are flawed by the lack of equivalence when equating or matching groups is claimed (see comments in Section 2.6.1) while others suffer from vagueness as far as delineating equivalence of groups goes. As with the selection of appropriate reading tests, considerable difficulties exist in finding an ability test differentiating the two groups on some common areas where both disabled and non-disabled readers would perform equally well. This would thus rule out verbally-biased ability tests as disabled readers would perform less well on these tasks than their age-peers. The procedure used by Doehring (1968) and also by Satz and associates (Satz and Nostrand, 1973; Sparrow and Satz, 1970) of using only the WISC Performance IQ to gauge group equivalence thus circumvents the verbal bias and is the more meaningful and acceptable. Note should be taken of the only partial dichotomy between the WISC verbal and performance ability as Maxwell (1959) has shown in a centroid analysis of the WISC that the component termed "verbal-intellectual" has high loadings on several of the Performance subtests as well as the Verbal subtests and that the component does not vary with age. It is possible that the verbal-performance dichotomy is much less clear-cut when applied to large samples of backward readers than it is the case with groups of severely disabled readers. With this latter group, a pattern of higher functioning in WISC Performance subtests and lower functioning on the Verbal Scale is found in a detailed profile analysis by Belmont and Birch (1966) when disabled readers are matched on full scale IQ with "normal" readers. Belmont and Birch stress that the finding of weaknesses on the Verbal Scale and strengths on the Performance Scale in the clinical group is not "idiosyncratic" and are careful in emphasizing their interpretation is most valid for the homogeneous samples studied (nine- to ten-year-old boys). Thus the use of WISC Performance scores in equating Group EX and Group CO seems justified.

In the present investigation, children in the Experimental Group had all been tested individually on the WISC within the preceding 6 months while those in the Control Group were administered the Lorge-Thorndike Intelligence Test Level III in the regular system-wide testing programme some time in April/May, 1973. The decision was made to equate the two groups on the basis of the WISC Performance IQ for the Experimental Group and the Lorge-Thorndike Non-Verbal IQ for the Control Group. To ensure greater comparability the Lorge-Thorndike Non-Verbal Test Level III was administered by the present writer in groups of about three children to the Experimental Group when the main investigation commenced early in October, 1973. The small group used and the careful explanation as well as working of the practice examples did much to arouse interest and sustain motivation with each of the three short subtests (9 minutes each). Comments will be made on this and related questions in later sections.

A summary of the sample characteristics in respect of age and ability level of the two groups is presented in Table 6-1.

Table 6-1

Means (M) and Standard Deviations (SD) of Age and Ability Level (IQ) of Experimental and Control Groups (N=58 Boys in Each Group)

Group		CA (in Months)*	IQ	
			WISC PIQ	Lorge-Thorndike Non-Verbal IQ
Experimental (EX)	M	111.069	105.086	102.448
	SD	4.781	12.559	11.495
Control (CO)	M	110.931		107.569
	SD	5.014		10.934

*As in October, 1973

The above characteristics (CA and Lorge-Thorndike Non-Verbal IQ) are shown in the histograms in Figures 6-1 and 6-2 respectively.

Inspection of both Table 6-1 and Figures 6-1 and 6-2 shows the teacher-selection of the children in respect of age and ability level was remarkably close to that expected. In two separate Hotelling T^2

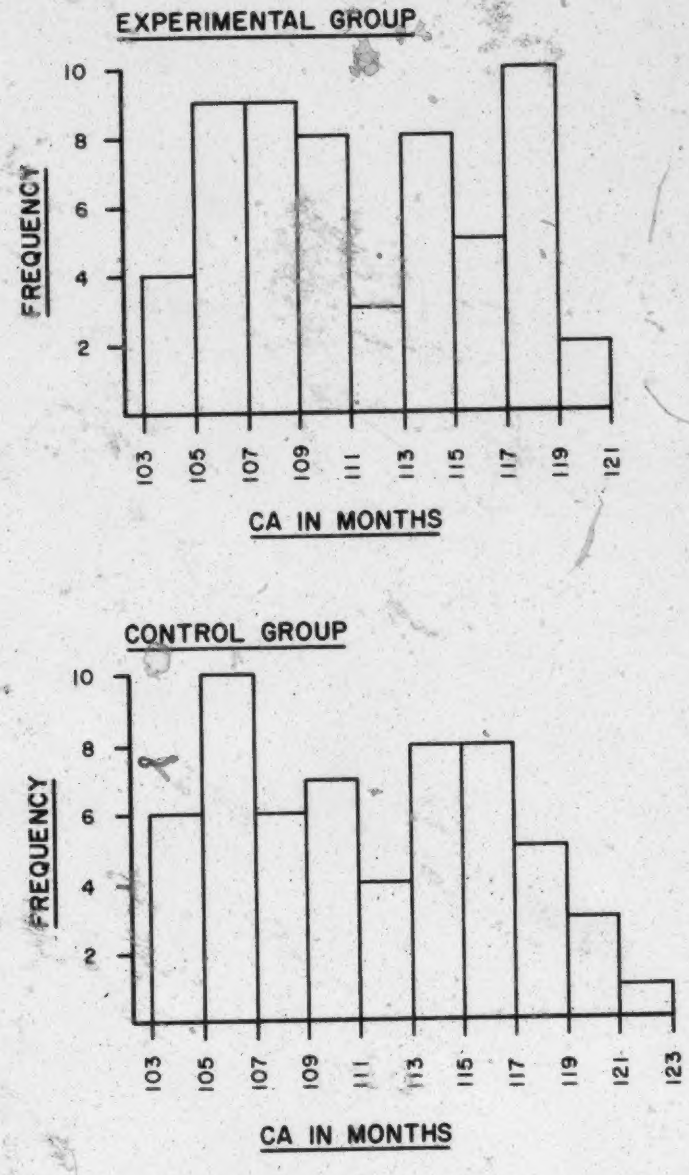
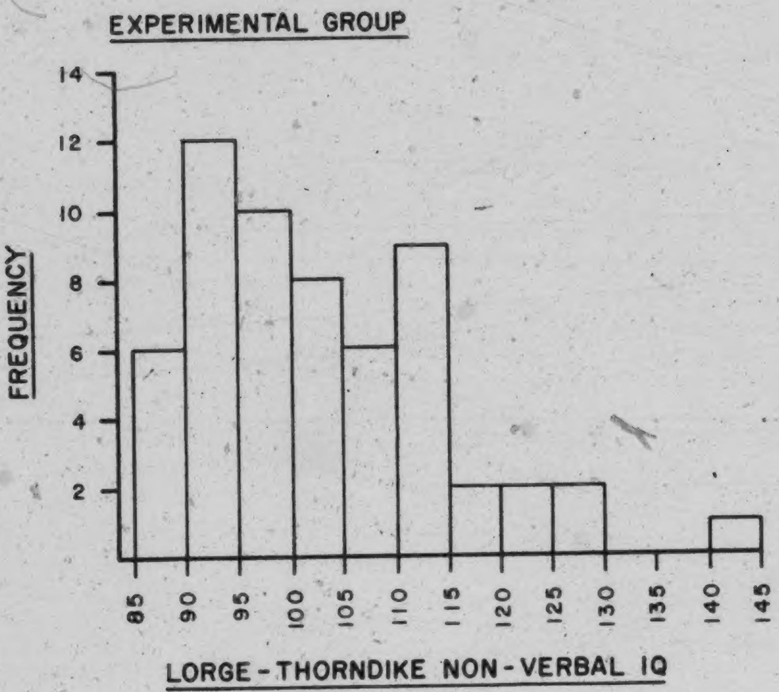


Figure 6-1. Histograms showing distribution of chronological ages (CA)-in months of two groups.



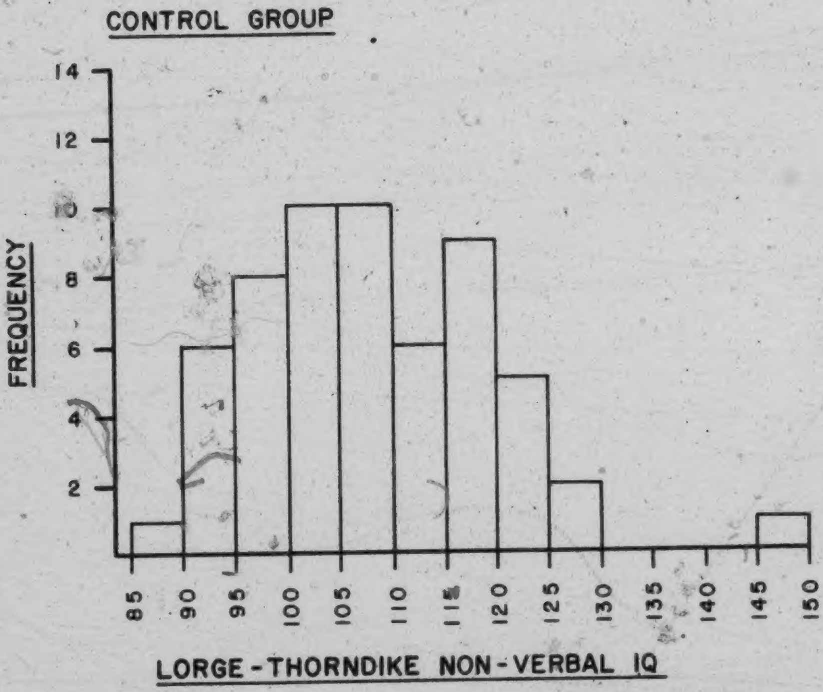


Figure 6-2. Histograms showing distribution of ability (Lorge-Thorndike Non-Verbal IQ, Level III, Form A) for two groups.

analyses (discussed in Chapter 7) involving the 8 main simultaneous-successive tasks as well there was no significant difference between the Experimental Group and the Control Group in Chronological Age and Lorge-Thorndike Non-Verbal IQ when the group centroids of these were considered simultaneously with other variables. In the Lorge IQ only plus the 8 tasks Hotelling $T^2 = 5.938$ which for df=9/106 gives an F ratio of 0.613 and a probability of 0.783. When both CA and Lorge IQ were included with the 8 variables the Hotelling T^2 for CA was 0.023 giving an F ratio of 0.002 and a probability of 1.000 (df=10/105) while for Lorge IQ Hotelling $T^2 = 5.938$ giving an F ratio of 0.547 and a probability of 0.853 for df 10/105. The use of the multivariate Hotelling T^2 should be preferred over the univariate t test as the former provides for the conjoint comparison of linear combinations of relevant variables. It would in fact be inappropriate to use a number of t tests as with a large number of t tests or comparisons there is the greater likelihood of committing Type I errors as a few comparisons may attain statistical significance by chance alone (Morrison, 1967; Tatsuoka, 1971).

To sum up, two equivalent groups of nine-year-old boys, one group severely disabled in reading and the other above average in reading but both groups equated on chronological age, sex and ability level as detailed above would be studied with a number of experiments and tasks pertaining to functional cerebral development and information-processing underpinning beginning reading.

6.3 Dichotic Stimulus Materials

Mention has been made of the technical problems confronting researchers in the preparation of dichotic tapes (Section 5.4) and of the improved instrumentation for the present investigation (Section 5.5). From the 7 tapes prepared by the present writer 3 were selected for each of the dichotic experiments (DL1, DL2, DL3). The stimulus materials are described below.

(a) For Dichotic Listening Experiment 1 (DL1) a list of 4 sets of digits with 5 series in each set ranging from 2-digit pair to 5-digit pair was used (see Figure 5-4 for illustration). The rate of presentation or inter-stimulus interval (ISI) was 2-digit pair per second as verified on the Hewlett-Packard 760 polygraph machine (Section 5.5 and Figure 5-11 and Figure 5-12). A 10-second response time was allowed on the tape at the end of each series. The digits 0 to 9 were used. "0" was pronounced as zero to avoid confusion with the letter "o" in Dichotic Experiments 2 and 3, "naught" being considered not suitable. Three practice examples were given preceded by 12 seconds of general instruction. Each set of 5 series was also preceded by appropriate instructions specific to that set. Each child was asked to report all the digits he heard via the set of earphones. The full dichotic list for DL1, a modification from that of Inglis and Caird (1963) and Neufeldt (1966), together with instructions is shown in Appendix B. A complete run of the tape from the general instruction through the practice examples to the last 5-digit pair takes exactly 6 minutes 56 seconds or approximately 7 minutes at a tape speed of 7 ½ inches per second (IPS), while the testing time up to the last 4-digit pair is 5 minutes 15 seconds. DL1 was designed to test mainly the hypotheses of lateralization effects in the two groups and the relative contribution of memorial and perceptual processes in dichotic listening.

Earlier, a trial tape with less than perfect synchrony was prepared using the Inglis and Caird list and tried out on a sample of some 30 mentally retarded children in Saskatoon in June, 1972. A refined version prepared from the present instrumentation with 1-digit pair to 5-digit pair series was tried out on some 40 retarded children in Edmonton in another experiment reported elsewhere as well as a few nine-year-old children not under study. On the basis of both observations and results it was felt that the set of 1-digit pair (1 digit to each ear) in the Inglis and Caird and Neufeldt list was far too easy while their set of 5-digit pair series (5 digits to each ear) was far too difficult as to induce indiscriminate guessing or frustration. Because of the ceiling and floor effects the list for DL1 began with 2-digit pair series. Scoring would take into account only the three sets of 2-digit pair series, 3-digit pair series and 4-digit pair series, making a total of 15 series in all. The different scoring methods are taken up in subsequent sections.

(b) Tape preparation for Dichotic Listening Experiments 2 (DL2) and 3 (DL3) followed the same procedure detailed in Section 5.5. For DL2 a list of 12 series of 3-element pairs consisting of a combination of 3 digits and 3 letters of the alphabet was used as suggested by Neufeldt (1966). The digits ranged from 0 (pronounced zero) to 9 while only 10 letters of the alphabet, "A, E, I. O, U, Y, L, M, R, X" were chosen. It can be seen that except for I and Y the letters were selected on the ground of minimum acoustic confusability. The 12 series were composed in such a way that 3 series contained no crossings (i.e., the digits were all on one channel and the letters on the other); 3 series with 1 crossing after the first pair; 3 series with one crossing after the second pair and 3 series with two crossings. The child was instructed to report all the combinations heard in one ear first and then those in the other ear (report by sides). The list together with the instructions is shown in Appendix C. As with DL1 the inter-stimulus interval was 1 second with a 10 second response time and a 20 second break half-way through (between the 6th and 7th series). The total tape run from the first of the five practice examples to the 12th series is 3 minutes 57 seconds at 7 ½ IPS tape speed. The instructions which were slightly more involved than those for DL1 were spoken by the investigator. Both DL2 and DL3 below were designed mainly to test the use of recall strategies by "sides" and "types" and the differential recall of digits and letters of the alphabet.

(c) For Dichotic Listening Experiment 3 (DL3) a list similar to that of DL2 was used. As with DL2 the inter-stimulus interval was 1 second with a response time of 10 seconds and a break of 20 seconds midway through the 12 series. The total tape run of 3 minutes 28 seconds includes 3 practice examples but excludes instructions. As with DL2, these were spoken by the investigator. The list for DL3 with instructions is shown in Appendix D.

6.4 Simultaneous-Successive Tasks

The tasks to test simultaneous-successive syntheses were selected on the basis of these criteria: (a) relevance to the theory as discussed in Chapters 3 and 4 and to the present investigation; (b) information available from previous research; (c) relative ease of administration; (d) reliability in the measures and objectivity of scoring. Of the 8 main tasks used, 6 were from the battery consistently used by Das (1972a, 1972b, 1973a, 1973b) and the remaining 2 from the Revised Illinois Test of Psycholinguistic Abilities (ITPA) (Kirk, McCarthy, and Kirk, 1968). These 8 tasks are:

(a) Raven's Coloured Progressive Matrices (1947) (RCPM)
(b) Figure Copying Test (FCT)
(c) Memory-for-Designs Test (MFD)
(d) Auditory-Visual Coding (AVC)
(e) Visual Short-Term Memory Task (VSTM)
(f) Auditory Serial Recall Task (ASR)
(g) ITPA Visual Sequential Memory Subtest (VM)
(h) ITPA Auditory Sequential Memory Subtest (AM)

Each of these will be commented on below.

(a) Raven's Coloured Progressive Matrices (1947) (RCPM)

The series of Progressive Matrices tests by Raven (1938, 1947a, 1947b) have been widely used internationally since their inception. Of the series, the Standard Progressive Matrices (Raven, 1938) first appearing in 1938 is the most popular. Sets I and II (Raven, 1947b), which first appeared in 1947 and which now contains a revised version of

Set II published in 1962, are for people over 11 years of age of "average or more than average intellectual ability" (Raven, 1968, p. 3). The Coloured Version (Raven, 1947a), appearing also in 1947 and consisting of 3 sets A, Ab and B with 12 items to each set, are for children aged 5 to 11 and for "clinical work." It is the Coloured Version with a maximum score of 36, which was used in the present inquiry.

As the three series are constructed on the same principles, discussions of the rationale of the Standard Progressive Matrices, which in the literature far outnumbers those for the other two versions, apply with equal force to the Coloured Version. Speaking of the Standard Progressive Matrices, Raven (1948, p. 12) states that it

> is a test of a person's present capacity to form comparisons, reason by analogy, and develop a logical method of thinking regardless of previous acquired information. . .

and maintains that "*by itself* it is not a test of 'general intelligence'" (author's italics). The same rationale holds for the Coloured Version which the author further describes as "a test of observation and clear thinking." (Raven, 1965, p. 3).

The development of analogy types of tests is usually accredited to the noegenetic principles of eductions of relations and correlates of Spearman who in turn attributed it to Burt (Spearmen, 1927). Burt (1921, p. 234) originally devised the matrix test as a supplementary test for dull and backward school children. Each item is a matrix of rank one where there is at least a two-way series numbers in proportion. Apparently, Raven (1965, 1968) overlooks this when he speaks of "each problem in the scale is really the 'mother' or 'source' of a system of thought." More on the meaning of this and on what Inhelder and Piaget

(1964) term "multiplicative classification" will be taken up in the discussion of rules, strategies in information-processing (Section 10.5). Despite criticisms of the inadequacy of the sampling procedure, norms (Anastasi, 1959; Burke, 1958; Shapiro, 1970) and of the narrowness in content, the Progressive Matrices is credited as a pure measure of "g" (Vernon, 1947, 1948; Foulds, 1949) or as what Jensen (1970) calls a pure "Level II" test relying on conceptual learning rather than "Level I" or associative learning. As well, the test was selected for the present investigation on the basis of studies of Das (1972a, 1972b, 1973a, 1973b) on simultaneous-successive syntheses.

(b) Figure Copying Test (FCT)

The Figure Copying Test (copy in Appendix H), often attributed to Ilg and Ames (1964), owes to Gesell's original Copy Forms Test. Gesell (Ilg and Ames, 1964, p. 34) merely seriated 6 forms in increasing order of difficulty from circle to cross to square to triangle to divided rectangle (British-flag-like) and finally to diamond. The Ilg and Ames version contains the Copy Forms Test plus two three-dimensional forms--a cylinder and a cube. The present Figure Copying Test (FCT) adds two more items--a diamond turned sideways with axes which are longer horizontally than vertically and a cuboid showing a different perspective. As they use it, Ilg and Ames emphasize the qualitative rather than the quantitative aspect of this visual-motor task: the way the child copies, the size form he makes, the place on the paper where he chooses to draw his forms and other qualifying categories rather than a mere FCT score. They also examine the developmental aspect of the task. But they are less than explicit in their claim (p. 34) that their version of the Figure Copying Test and a number of their other tests "undoubtedly tap sub-verbal levels of the brain."

This claim could probably be better understood by relating the Figure Copying Test to the constellation of tests tapping visual-motor integration. Variant members of the group include: the Bender-Gestalt Test (Bender, 1938) particularly the Koppitz Version (Koppitz, 1964); the Benton Visual-Motor Retention Test (Benton, 1955); the Goodenough-Harris Draw-a-Person Test (Harris, 1963); the Memory-for-Designs Test (Graham and Kendall, 1960); to name just a few key ones. All these integrative tasks have been found useful clinically as screening instruments for brain dysfunction and they relate directly to the discussions of hemispheric specialization in Chapter 3. With his immense experience with pathological cases behind him, Luria (1966a, 1966b, 1970b, 1973) suggests that successful performance in visual-motor tasks presupposes the organization of a set of symbolic coordinates such as right-left, up-down, before-behind, which develop on the basis of experience and language. The integration of inputs relates to an intact parieto-occipital area and in particular, the tertiary zones of the inferior parietal gyrus (see Figure 3-2). Thus the investigation of visual-motor integrative functions is important in diagnosing learning disorders including reading. While agreeing with Ilg and Ames (1964, p. 63) that the apparently simple, as with figure copying, can tell the profound, the present writer had at first some misgivings about possible ceiling effects with the Figure Copying Test when applied to children in middle childhood rather than pre-schoolers for which the FCT is intended. In particular, the lack of clarity in awarding scores of 0, 1 or 2 to each drawing according to its degree of correctness needed improvement and for this purpose a set of general and specific principles of scoring was drawn up by the present writer (see Appendix I). As the results show, the task can still be discriminating at the higher age level. The writer, as do many others, proved to be equally right and wrong--wrong for the right reasons, or right for the wrong reasons. These apparent paradoxes will be taken up in the discussion of results.

(c) Memory-for-Designs Test (MFD)

The Memory-for-Designs Test (Appendix J) dates back to nearly thirty years of co-operative search for research and clinical tools for "*possibly* brain-damaged patients" (Graham and Kendall, 1960, p. 148, the writer's italics) by Graham and Kendall (Graham and Kendall, 1946; Graham and Kendall, 1960; Kendall and Graham, 1948). In addition, Lyle (1968), among others, has shown that the test differentiates between "retarded" and adequate readers. Mention has been made of the relationship of the Memory-for-Designs Test to variant members of the constellation of visual-motor integrative tasks. Where the MFD differs from, say, the Bender Gestalt in that group of tests is the combination of components of memory, appropriate complexity of designs and "general intelligence level of Ss" (Graham and Kendall, 1960, p. 173). There are 15 different designs with a five-second exposure time for each design at the end of which the child reproduces from memory the drawing seen. Responses are scored for errors on a scale ranging from 0 to 2 or 3 with 0 as the "best" score (the least error) and 3 as the "worst" (the most error). Reasonably adequate scoring criteria are given in Graham and Kendall (1960). As will be shown later, the rationale for awarding scores of 0, 1, 2 or 3 needs to be more clearly delineated and methods of scoring improved on. The Test was used in the present study of the simultaneous-successive syntheses as Das (1972a, 1972b, 1973a, 1973b) has shown the task has a large component of the simultaneous.

(d) Auditory-Visual Coding (AVC)

Rather than the generic term cross-modal coding (CMC) which can encompass visual-auditory-tactile-kinaesthetic modalities, the more specific label auditory-visual coding (AVC) is adopted to denote the test used. The task is modified from that developed by Birch and Belmont (1964) and has been used by Orn and Das (1972). Typically, the child listens to patterns of sound (e.g., tap, tap--long pause--tap, tap) following which he is asked to recognize visual dot patterns (e.g., oo oo/oo oo/oooo) corresponding to the auditory stimuli. There are 10 such items with test stimuli ranging from combinations of 4 auditory patterns to up to 7 patterns (schematically illustrated in Appendix K). Here again there is slight variation in the duration of the pauses between the stimuli amongst workers. Apart from the occasional 500 cycle tones (e.g., Beery, 1967), most workers use 1000 Hz. discrete tones (Bryden, 1972; Vande Voort, Senf, and Benton, 1972) and it is the region between 1000 to 2000 Hz. that the human ear shows maximum sensitivity (Broadbent, 1971, p. 117). The duration for each of the auditory stimuli and the intervals of pauses between them and the nature of dot patterns as used by some researchers are shown below.

Researcher(s)	Auditory Sequential Patterns in Seconds			Visual Dot Patterns
	Duration of Each Tone	Short Pause	Long Pause	
Beery (1967)	0.6 (approx.)	0.4	0.9	5" x 8" cards, 1 cm for "dots within a group, 6 cm between groups"
Birch and Belmont (1964, 1965)	tapping with pencil in full view of subjects	0.5 approx.	1.0 approx.	Visual dot patterns
Bryden (1972)	0.25	approx. 0.75 for a "discontinuity"		a) visual sequential patterns (¼ light flashes) b) visual spatial dot patterns
Orn and Das (1972)	0.15	0.35	1.35	Visual dot patterns on cards
Vande Voort, Senf, and Benton (1972)	0.1	0.4	0.9	Dots on 2" x 2" slides for rear projection approx. 0.5 cm and 1 cm between dots for short and long pauses

It is clear that the 0.6 second used by Beery, which is longer than the short pause between patterns, is too long. The original Birch and Belmont pencil tapping in full view of the children confounds auditory with visual stimulation and leaves something to be desired. A variation of the auditory-tone-visual-dot (AVC) pattern is that of Blank and associates (Blank and Bridger, 1966; Blank, Weider, and Bridger, 1968). In their work with young children they use the method of gradually introducing temporal components into spatially presented materials by flashing lights simultaneously (spatial presentation) and later flashing these lights in temporally successive groups. In the present inquiry the auditory stimuli used consisted of 1000 Hz. discrete tones of 0.2 sec. duration with the short pause lasting 0.4 sec. and the long pause 1.2 sec. The visual stimuli consisted of deca-dry 24 pt. black dots 2 cm in diameter and with a short space of 0.5 cm between 2 dots and a long space of 2 cm. Each dot-pattern was enclosed in a 7.5 cm x 1.2 cm rectangle for easy identification. On each card measuring 15 cm x 10 cm there were 3 patterns with various combinations of dots separated by short or long spaces. The child was asked to choose the one visual pattern corresponding to the tone patterns.

The theoretical underpinning and some current work with the auditory-visual coding paradigm has been briefly discussed in Chapter 4 and will not be repeated here. Suffices it to say that this deceptively simple cross-modal coding behaviour has begun to be viewed as an area of possible major significance in the learning difficulty of disabled readers. Apart from the quantitative differentation between disabled and average readers there are important unresolved theoretical issues.

These include: the conceptual as well as perceptual basis of cross-modal coding; the role played by intra-modal coding vis-a-vis inter-modal coding within the stricture of Bryant (Bryant, 1968; Milner and Bryant, 1970) for control of both; the meaning of correspondence or equivalence between, say, auditory-visual stimuli; the role of modalities vis-a-vis temporal-spatial dimensions; the role of verbalization as suggested by Blank and associates (Blank and Bridger, 1966; Blank, Weider, and Bridger, 1968). In short, a clearer delineation of the nature of inter-sensory integration. Some of these important issues will be further developed in the discussion on "Strategies and Tactics" in Chapter 10.

(e) Visual Short-Term Memory Task (VSTM)

This is the same task used by Das (1972a, 1972b, 1973a, 1973b; Orn and Das, 1972) in his study of simultaneous-successive syntheses. The visual task[1] consists of 20 separate slide presentations of five-digit grids as illustrated in Appendix L. The child views each grid for 5 seconds, and is required to perform for 2 seconds a neutral filler task of colour naming to prevent rehearsal. At the end of the 7-second duration a blank slide will be shown and the child will recall the 5 digits first seen by writing them down in their exact positions on a pro-forma. Presentation of the stimulus slides is controlled by a Kodak Carousel 850 projector and a series of interval timer. The stimulus materials and the schematic of operation are shown in Appendix L. Scoring is by the total number of digits in the correct grid position recalled by each child and the maximum for the 20 items with 5 digits each is 100. The strategies required for the performance of this task are discussed later.

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[1] Stimulus materials originally developed by Drs. E. Howarth and J. Brown of the University of Alberta.

(f) Auditory Serial Recall Task (ASR)

The task is essentially part of the Auditory Short-Term Memory test used by Orn and Das (1972) who in turn acknowledge their indebtedness to Baddeley (1964, 1966). The latter observed that acoustic similarity in words interferes more with short-term memory whereas semantic similarity more with long-term memory. Each list of acoustically similar words forms an integrated whole and in the present study only the former list was used. This consisted of 12 sets of four-word series drawn at random with replacement from a pool of acoustically similar words and another 12 sets of four-word series drawn in a similar way from a pool of control words. The words in each category were as follows:

Acoustic: mad, man, mat, cap, cat, can, cab, pan, tap.

Control: cow, day, bar, pen, few, hot, key, wall, book.

Thus there were 24 sets of four-word series (Appendix M) and the order of these series was mixed. The final 24 sets of words were recorded on magnetic tape at the rate of one word per second with an inter-series recall time of 15 seconds, and played back to the children from a tape recorder at a comfortable hearing level. A rest period of about 1 minute was given after the first 12 series. Scoring was according to the words reproduced verbally in their correct serial position. The free recall scoring was not used as it was felt that the method of presentation without any noise interference would be too easy and would lead to a ceiling effect. This task has been found by Das (1972a, 1972b, 1973a, 1973b) to load on the successive dimension. Here again, one might examine the strategies used by the children. How do they retain four monosyllabic words which are acoustically confusing? What is the relationship of Auditory Serial Recall to the other tasks in the simultaneous-successive matrix? These and other questions are taken up in subsequent sections.

(g) ITPA Visual Sequential Memory Subtest (VM)

The ITPA Visual Sequential Memory Subtest (VM) (Kirk, McCarthy, and Kirk, 1968; Paraskevopoulos and Kirk, 1969) consists of 25 sequences of discrete non-meaningful, abstract figures varying in length from two through eight figures (sample in Appendix N). The child is shown each sequence of figures for five seconds and then asked to place the plastic chips of corresponding figures in the same order on the tray. Two trials are allowed per sequence when necessary and scores of 2, 1 or 0 are given according as to whether the answer is correct on the first trial, correct on the second trial or incorrect. Correctness is taken to mean exact sequential or simultaneous arrangement of the chips by the child from left to right on a plastic tray to correspond to the pattern shown him. This task was included not only for its diagnostic value (Kirk and Kirk, 1971; McLeod, 1965) but also for the strategy the task calls forth in the simultaneity-successivity nexus. This will be taken up subsequently.

(h) ITPA Auditory Sequential Memory Subtest (AM)

The ITPA Auditory Sequential Memory Subtest (AM) (Kirk, McCarthy, and Kirk, 1968; Paraskevopoulos and Kirk, 1969) consists of 28 digit sequences ranging in length from two to eight digits (list shown in Appendix O). The digit sequences are chosen with a view to ensure: (a) equal frequency of occurrence and even distribution of digits in the subtest; (b) avoidance of consecutive digits in adjacent positions in a sequence whether forward or backward; and (c) non-occurrence of the same element in immediate succession. The digits are presented at the rate of two per second. Two trials per sequence are allowed, with more credit given for the first trial success (score of 2) than for the second (score of 1). It can be seen that the task is a short-term memory task derivable from such as Digit Span (DS) in the WISC. The ITPA Subtest was selected rather than the WISC Digit Span because of the high median internal consistency coefficient of 0.90 for AM. It should also be noted the very recent revised WISC-R (Wechsler, 1974) also adopts similar methods of two-trial presentations.

A word or two about Digit Span or related tasks is in order although space necessarily precludes any extended discussion. Some interesting insight into the nature of these tasks is provided by Wechsler (1958, p. 71) himself in the succinct statement:

> Except in cases of special defects or organic disease, adults who cannot retain 5 digits forward and 3 digits back will be found, in 9 cases out of 10, to be feeble-minded or mentally disturbed.

and

> Rote memory more than any other capacity seems to be one of those abilities of which a certain absolute minimum is required, but excess of which seemingly constitutes relatively little to the capacity of the individual as a whole.

As an aside, Wechsler shows in his second statement remarkable foresight and insight into what Jensen (1969, 1970) calls Level I and Level II cognitive abilities, which the latter has backed with both theoretical and extensive empirical evidence. Wechsler, however, has been shown to be overly pessimistic in his first statement although the general tenor is correct. In fact, he considered rejecting Digit Span from the WAIS because of the low correlation of DS with other subtests but retained the subtest only because of its diagnostic value. In this he is proven right both experimentally and clinically. Experimentally as witness the celebrated magical number 7 ± 2 (Miller, 1956). Clinically as evidenced in the number of studies supporting the efficacy of DS in discriminating between disabled and non-disabled readers (Altus, 1956; Belmont and Birch, 1966; Dockrell, 1960; Hirst, 1960; Lyle and Goyen, 1969; McLeod, 1965; Neville, 1961). While almost all the workers quoted relate the performance on digit span of disabled readers or other exceptional children to defects in short-term memory or in attention, the Das interpretation within Luria's mode of successive processing is refreshing. This dimension, it is felt, can be extended or expanded into the whole of simultaneity-successivity matrix and information-processing in Chapter 3 and Chapter 4.

The highly condensed comments on the above tasks hardly do them justice. To summarize their roles in the scheme of things from a priori evidence and in the Luria-Das paradigm, one could say the predominantly "simultaneous" tasks are: Raven's Coloured Progressive Matrices, Figure Copying, Memory-for-Designs; the predominantly "successive" tasks are: Auditory Serial Recall, ITPA Auditory Sequential Memory; while the remaining 3 tasks: Auditory-Visual Coding, Visual Short-Term Memory and ITPA Visual Sequential Memory may straddle the two domains as a function of processing strategies and depending on the groups tested. What then is simultaneous? Successive? The whole simultaneous-successive matrix? What are the processing strategies that children use? For empirical findings and psychological interpretations we turn to the ensuing chapters.

6.5 Review

This chapter sets forth the formulations and hypotheses of two parallel but integrated studies. Study I pertains to the main formulation of functional cerebral development, which is tested via 3 dichotic listening experiments consisting of digits and combinations of digits and letters of the alphabet. Study II relates to the second main formulation of simultaneous-successive syntheses verifiable through tasks known to load on these dimensions. The rationale is described for the status inquiry of an experimental group of 58 nine-year-old boys with specific reading disability compared with a control group of the same number of above-average readers of the same age, sex and ability level. Methodological problems encountered in equivalence for ability and in gauging reading levels of the groups are explained and actual sampling procedures detailed. The 3 dichotic listening stimulus materials and the 8 main simultaneous-successive tasks are described in some detail. Comments on the tasks are offered to gain greater insight into them for a clearer understanding of the strategies and tactics of the children in performing these tasks. As Sir Hughlings Jackson taught nearly 120 years ago, whether the patient succeeds in a test or not is less important than how the patient does it. So it is with our children. The chapter also includes a note on the administrative arrangement of the field work in the 16 different schools with the 116 children.

CHAPTER 7

RESULTS AND DISCUSSIONS OF STUDY I--THREE DICHOTIC LISTENING EXPERIMENTS

> It is paradoxical to assume a succession which is nothing but succession but which nevertheless takes place in a single moment.
>
> Paul Fraisse in The Psychology of Time, 1964, quoting H. Bergson in Durée et Simultanéité, 1922.

The theoretical underpinning of research strategies and data reasoning derives from two main sources: Cronbach (1957) and Tukey (1969). Cronbach's dictum for a "united discipline" in using both experimental (studies of variance among treatments) and correlational (studies of variance among organisms) procedures is generally followed in the related dichotic experiments and simultaneous-successive tasks. An attempt is made to act on his advice for the psychologist not to lose himself in the "narcissistic program of studying his tests as an end in themselves" and not to enthrone "theory of test performance in the place of theory of mental processes." (Cronbach, 1957, p. 675). Tukey (1969, p. 83) states that "one body of data can--and usually should--be analyzed in more than one way" with the proviso of not bending the question to fit the data. His canon of careful but flexible data analysis together with the use of conjoint measurement provides the rationale for data reasoning to be discussed presently.

7.1 Testing Procedures and Scoring

In Study I the "yoked" design or counter-balanced design was used in each school with the three dichotic listening experiments. In other words, when child 1 received channel 1 in his right ear, child 2 received the same channel 1 in his left ear, the order of testing the children being randomized. In Dichotic Listening 2 (DL2) and Dichotic Listening 3 (DL3) the same principle applied. Thus in DL2 half of the children in the school would report all the stimuli (digits and letters of the alphabet) heard in one ear (left or right) first and then those heard in the other ear, order of testing being randomized. In DL3 half of the children in each school would report either the digits first, then the letters of the alphabet, and the other half the letters before the digits, order of testing again randomized. All playback was via the Sony 777-4J with a pair of Sony earphones for the children and an additional pair of matched Sony earphones specifically fitted to enable the investigator to monitor the stimuli. A dual channel Uher served as a back-up machine. Care was taken to ensure a comfortable hearing level and to maximize performance for the short tasks varying from an actual testing time with earphones on of a little more than 4 minutes to 7 minutes. Close observation during sessions confirmed Bryden's (1962, p. 293) suggestions that the likelihood of guessing the digits is extremely low. Scoring procedure, which may affect the results, are discussed in the next paragraphs.

The scoring of the responses in general followed the procedure used by Broadbent (1954, 1956, 1958), Bryden (1962), Inglis and Sanderson (1961) and Neufeldt (1966). The first digit/element reported by the child determined in each case which channel was taken to be the half-span recalled first. This is in accord with both the perceptual and memorial models of dichotic listening paradigm discussed in Section 5.2. There are two main methods of report by subjects when they make free responses in dichotic listening experiments: an ear order report and an attempted ear order report.

7.1.1 Scoring for Ear Order--Dichotic Experiment 1

An ear order report follows the pattern of

$$\begin{tikzcd} L\ (R) & 1 \arrow[r] & 2 \arrow[r] & 3 \arrow[dll] \\ R\ (L) & 4 \arrow[r] & 5 \arrow[r] & 6. \end{tikzcd}$$

Thus if the presentation is left ear 1-2-3/right ear 4-5-6, then at fast rates (as in the present studies) the maximal efficiency of recall would be with the order 4→5→6→1→2→3 or 1→2→3→4→5→6 (see also the extension of dichotic tasks by Moray, Bates, and Barnett (1965) to the "four-eared man"). Classifying a response sequence in this way does not require that the subject identify all the numbers correctly. Either overt errors or omissions can occur with the response sequence. This is probably the rationale behind the scoring method of Moray and Barnett (1965) in incorporating errors of omission and commission. This is unnecessarily cumbersome and does not lead to appreciably different results. Moreover, since all the stimuli are drawn from a total of 10 digits (0 to 9) and a small number of letters, it seems difficult to justify forms of scoring more complex than those reported here (see also Inglis and Sykes, 1967).

In the scoring for ear order effect the number of digits reported corresponding exactly to the actual number in the first channel is scored according to the proper serial position of the digit series and similar procedure follows for the second channel. Thus for the 3-digit

pair series (a) L 6-5-9 a response of (6)-4-(9)¦-(7) indicates the
R 7-4-2

left half-span is recalled first and the correct score is for L=2 and R=1 (shown in brackets). The next example comes from a 4-digit pair

series. For (b) L 7-1-5-2 a response of (2)-7-2-(6)¦-2-5 shows
R 2-4-3-6

the first four digits are from the right ear with a R score of 2 for the two correct digits in the correct serial position ((2) and (6) shown in brackets) while the L score is 1 with either the 2 or 5 scored as correct, but not both, as the serial position is reversed. This method of scoring by ear-order of report taking into account serial position is more stringent than the attempted ear order report.

7.1.2 Scoring for Attempted Ear Order--Dichotic Experiment 1

An attempted ear order is explained as any systematic temporal order of reporting taking into account only correct digits for each channel but disregarding serial positions. For the same two examples

L 6-5-9 the same response of 6-4-9-7 would give a L score of =2 and
R 7-4-2

R=2 as shown by the arrows. For example (b) of L 7-1-5-2
R 2-4-3-6

the same responses of 2-7-2-6-2-5 is scored as L=3, R=2 as contrasted with the ear-order report of L=1, R=2. The flow of scoring is shown

as L 7-1-5-2 score of 3 or as L 7-1-5-2 score of 3
R 2-4-3-6 score of 2 R 2-4-3-6 score of 2.

Where there is a difference in the flow of temporal order the different scores are summed and the mean taken. An example is from the response of 4-6-3-6-7-3 to (c) L 5-1-6-4 score of 1
R 4-8-1-6 score of 2

The score of L=1 and R=2 is shown, but the same response under an attempted ear order report could reverse the score to L=2, R=1 when the reporting starts from the 4 in the left series. The final attempted ear order effect is thus L=(1+2)/2 or 1.5 while R score is given by R=(2+1)/2 or 1.5 as compared with an ear order report of L=0, R=2 for (4)-6-3-(6)¦7-3. One more example will be appended to illustrate the two orders of report: (d) For the response 3-7-5-2-6 to L 3-7-5-2 the different attempted
R 9-1-2-3

ear orders as shown has an average L score of (4+3+2+3)/4=3 and a R score of (0+1+2+1)/4=1:

i)	ii)	iii)	iv)
L 3-7-5-2	L 3-7-5-2	L 3-7-5-2	L 3-7-5-2
R 9-1-2-3	R 9-1-2-3	R 9-1-2-3	R 9-1-2-3
L = 4	L = 3	L = 2	L = 3
R = 0	R = 1	R = 2	R = 1

This score of L = 3, R = 1 may be compared with the ear order score of L = 4, R = 0.

The four examples illustrate the two modes of report: the ear order report and attempted ear order report for each dichotic series. For scoring purposes the series of digit sequences is the basic unit.

Foe each series length there are 5 series which comprise a set. Three sets of 2-digit, 3-digit and 4-digit series comprise a dichotic list for the respective half-spans (see Appendix B for Dichotic Listening Experiment 1 or DL1 list). The score for the set of 5 series is obtained by summing the left or right scores of the series. Similarly the score for each list in respect of each half-span is the sum of the sums of each of the 2-digit, 3-digit and 4-digit sets or of 15 series altogether. Where necessary, the total for each set will be converted into proportions which are subjected to arcsin transformations more for additivity effects rather than for stabilizing the variance (Winer, 1962, pp. 218-222). This transformation for additivity effect implies a model relatively free from interaction terms. This was in fact done in some of the analyses to achieve better interpretability when different series were compared. From the explanation of the rationale of two modes of reporting and the examples of scoring it can be seen that while the ear-order report is more stringent, the attempted ear order report preserves some information which may otherwise be lost and takes care of all possible splits in an analogy with reliability studies in reporting.

7.1.3 Scoring for Sides and Types (Dichotic Experiments 2 and 3)

What has been said pertains mainly to scoring with free responses as with Dichotic Listening 1 when children simply reported all the digits they heard. With Dichotic Experiment 2 and Experiment 3 (see Appendices C and D respectively) specific strategies were used. With Dichotic Experiment 2 half of the children were instructed to report the combination of digits and letters heard in one ear first and then

those heard in the other ear while the other half would reverse the order. This strategy would be called *sides* or *ears* strategy. In Dichotic Experiment 3 half of the children were instructed to report the digits first and then letters while the other half would report the letters first then digits. This would be called *types* strategy. Since specific instructions of reporting were given and since only three elements were involved in each half-span the main scoring method was that of *serial* scoring. By this is meant that the first three elements reported should accord with the specific sides instruction (left (ear)/right (ear) first) or the specific types instruction (digits/letters first) and the digits or letters reported should correspond to the actual serial positions of the stimuli. This is illustrated with the response of u-(6)-9¦-y-8- DK
to e) L/R u-m-1 when the specific instruction is to report all the
R/L 9-6-8
digits first then letters of the alphabet. Here the total score for serial scoring is 1 as "6" is the only *serially* correct element in the proper *serial* position according to the pre-instructed strategy while "6-9" or "8" followed by "don't know (DK)" are not in their correct positions. Similarly, the responses of 9-6-0¦-(r)-(u) to:

f) L/R 8-4-o with instruction to report digits first then
R/L r-u-2

letters gives a total score of 2 as shown. It should be noted that the total score for the main analysis does not differentiate the correct serial score for digits or for letters. In this case, a further split of the score of 2 would be a score of 0 for digits but a score of 2 for the correct letters r-u. Another example according to the letters first then digits strategy is the response of (m)-(x)-y¦-(9)-(2)-(7) to:

g) L/R 9-m-x with a serial score of 5 as shown. A variation of
R/L y-2-7

the serial scoring is the free scoring method which takes into account all correct elements irrespective of the sides or the types strategy or serial positions. Thus in the first example (No. e) of (u)-(6)-(9)-y-(8)-DK in response to L/R u-m-1 the "free" score is 4. With the second
R/L 9-6-8

example above (No. f) the free score is 3 instead of 2 while with the third example (No. g) it is 6 instead of 5. It can thus be seen that again the serial scoring is more stringent whereas the free scoring may provide some additional information.

In the preceding paragraphs considerable detail has been given on the rationale and method of scoring as there is a paucity of information in the literature and as different methods of scoring might make for slightly different results. It should be emphasized that scoring by ear order or attempted ear order in a free response situation is more applicable to dichotic series where there are sequences of 2-, 3-, 4- or 5- elements. With a two-response paradigm involving only one discrete element, say a syllable, to each ear, then the usual laterality index is by $\frac{R - L}{R + L}$ where R = the number of correct right-ear responses and L = the number of correct left-ear responses. This index is used by Bakker (1973), Irvine (1972), Orlando (1972), amongst others. This accepted procedure, however, raises methodological problems as it has been shown that for the identification of both stimuli on each dichotic presentation, the maximum value of the index decreases rapidly, as overall performance rises above median difficulty (50 percent). To overcome or minimize this ceiling effect Krashen (1972, personal communication) suggests the need to examine error scores and the Haskins group has proposed some promising methods (Studdert-Kennedy and Shankweiler, 1970; Kuhn, 1972). The phi coefficient of Kuhn is especially attractive as an attempt is made to provide for critical values of the laterality index. It should be further emphasized that these refined methods from the general theme of $\frac{R - L}{R + L}$ apply strictly to the two-response pattern and relate more to the different ear effect in an individual and less for groups. Thus the Krashen, Studdert-Kennedy and Shankweiler and particularly the Kuhn methods are more suited to the fine-grained clinical and acoustic studies when sample size is small and the number of two-response trials is often as large as 100 or more. These generally excellent but little known (in psychological circles) sources are mentioned because of their contribution to methodology. These also help measure individual differences in lateralization.

7.2 Results and Discussions of Dichotic Experiment 1

In Dichotic Listening Experiment 1, as in Dichotic Listening Experiments 2 and 3 (DL2, DL3), the fixed-effect analysis of variance (ANOVA) designs with repeated measures are used for the analysis of data. Specifically the main method is the two-factor ANOVA with repeated measures in one factor together with the three-factor ANOVA with repeated measures in two factors. Where appropriate homogeneity of covariance is tested as enjoined by workers in the field (McCall and Appelbaum, 1973; Poor , 1973). Again, where appropriate, analyses would be by the ear order and attempted ear order reporting and by serial and free scoring so as to achieve results relatively independent of different report or scoring methods.

As discussed in Section 6.1.1 Dichotic Listening 1 was designed to test mainly differential lateralization effect and the differential contribution of memorial and perceptual processes to dichotic listening. Attempts to verify Hypotheses 1, 2 and 3 are provided in the results which follow.

7.2.1 Hypothesis 1--Overall Lateralization Effect

Hypothesis 1 with its riders that both the Experimental Group (Group EX) and the Control Group (Group CO) would show an overall right ear effect in both ear order and attempted ear order reporting with Group CO performing better than Group EX was tested with a two-way group (EX and CO) x half-span (left and right) ANOVA repeated measures analysis with the left/right ear collapsing across series lengths being the repeated measure. Table 7-1 shows the mean scores of the two groups for the ear order and the attempted ear order reporting when scores were summed across series lengths (i.e., the total of the 2-digit, 3-digit, and 4-digit sets of 5 series each).

The results for the two groups and the left/right half-spans were analyzed in two separate repeated measured ANOVA, one for the ear-order reporting and one for the attempted ear reporting. In both analyses left/right half-span was the repeated measure. With a two-way ANOVA repeated measures design involving only two measures on each subject

Table 7-1

Means (M) and Standard Deviations (SD) of Left/Right Scores for Two Groups (N=58 in each Group) and Two Methods of Scoring

Group		Ear Order		Attempted Ear Order	
		Left	Right	Left	Right
Experimental (EX)	M	17.26	20.10	25.66	29.59
	SD	5.46	6.36	6.62	4.83
Control (CO)	M	18.79	24.21	29.97	34.06
	SD	5.84	5.57	4.65	4.07

there is only one covariance and there is no possibility of heterogeneity of covariance. Hence the problem of homogeneity of covariance, or the lack of it, does not exist and the analysis of the within subjects effect is equivalent to an analysis of difference scores between the repeated measures (McCall and Appelbaum, 1973; Winer, 1962, p. 316). The main effects of group and half-span are highly significant for both methods of reporting with both the Experimental Group and the Control Group performing better in the right-ear while Group CO obtaining higher scores than Group EX. With ear order reporting the F-ratio for group = 14.761, $p < 0.001$ and for half-span F = 26.269, $p < 0.001$; both with 1/114 df. With attempted ear reporting the F-ratio for group = 37.247, $p < 0.001$ and for half-span F = 39.537, $p < 0.001$; both with 1/114 df. Thus Hypothesis 1 together with its riders 1a, 1b and 1c is upheld. In other words, a lateralization effect is found with both disabled and non-disabled readers considered as groups and that the latter group shows a stronger right-ear effect than the former. This differential lateralization is relatively "method-independent" as shown with two orders of report. These results are shown graphically in Figure 7-1.

The slopes in the graph shows that with the ear order reporting the group differential for the right-ear effect is larger than for the left-ear effect. This may be due to differential lateralization or to differential memory storage/retrieval load as discussed in Section 5.2. The result could also be from the combination of both perceptual and memorial processes, as the contribution of each is difficult to ascertain. Whether the reason of cerebral asymmetry or short-term memory is advanced, it is clear the scores reported first are better than those reported second. It is also interesting to note that this differential is less with the attempted ear order as shown by the almost parallel lines in the right half of Figure 7-1. The reason is possibly that by taking into account all possible "splits" of responses the attempted ear order provides for less accentuated left/right ear scores while maintaining the superiority of the latter.

It cannot be emphasized too strongly that the results found so far, as with subsequent findings, relate to the children considered as groups and individual differences are not adequately catered for. This will be further discussed. It should also be pointed out that the size of the differential ear score should not be taken as the absolute degree of lateralization (see Studdert-Kennedy and Shankweiler, 1970), as the nature of the stimuli, task difficulty, rate of presentation and other relevant factors all contribute to the differentials.

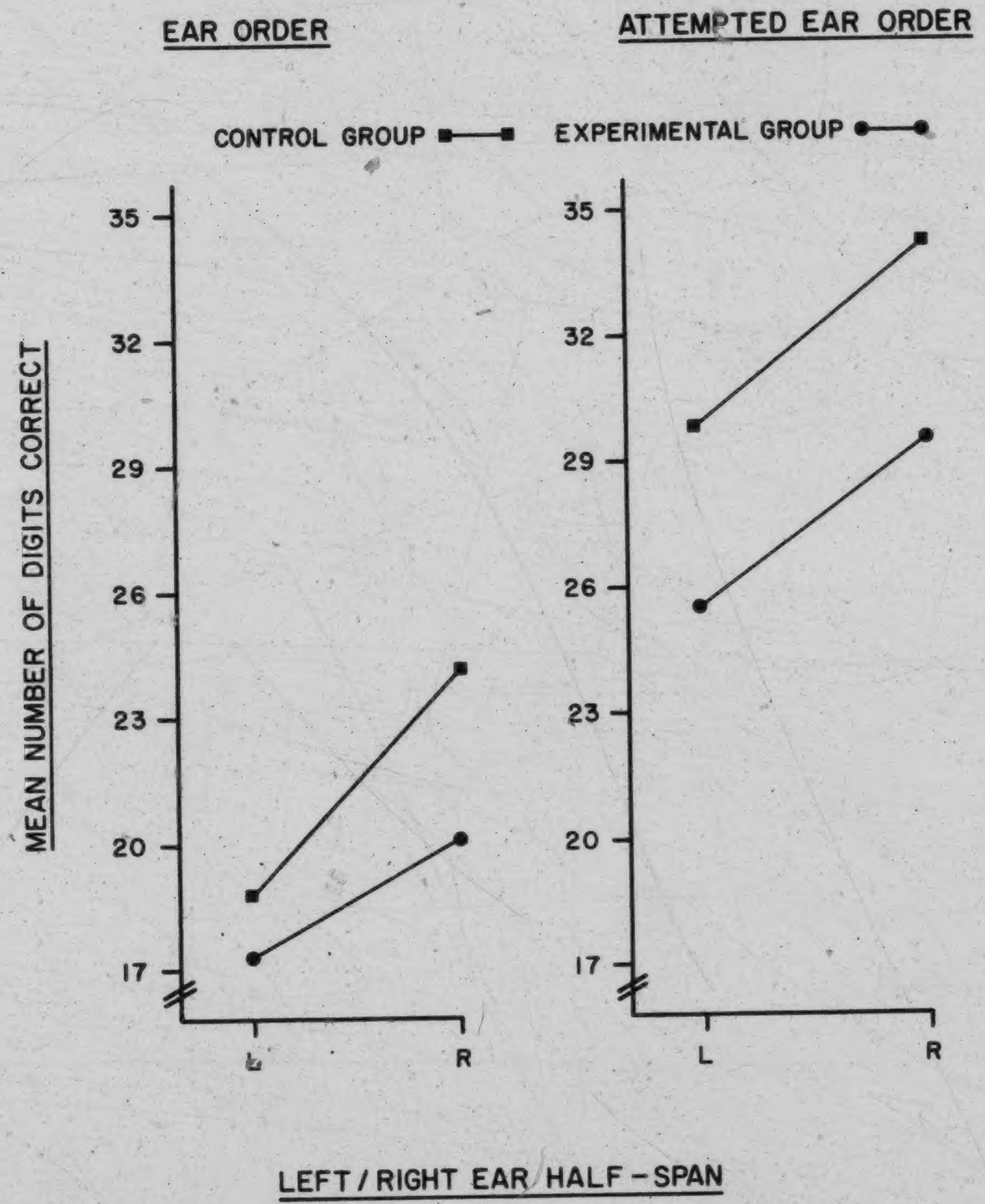

Figure 7-1. Mean number of digits (collapsed across series lengths) recalled by experimental and control groups for each half-span for two methods of scoring.

7.2.2 Hypothesis 2--Relative Contribution of Perceptual and Memorial Processes

Hypothesis 2 that the ear difference could be attributed to a combination of perceptual and memorial processes was tested again with two related two-way ANOVA repeated measures analyses. In the first ANOVA left and right half-spans reported first and collapsed across series lengths were the repeated measures while in the second ANOVA left and right half-spans reported second and similarly collapsed across series lengths were the repeated measures. The scores for the left/right digits reported first and the left/right digits reported second were obtained by breaking down the ear order scores for each series according as to the primacy of the left/right ear reporting and by summing over each set of 5 series and again over each list of the 3 sets of 2-digit, 3-digit and 4-digit pairs. Thus in example (a) shown in Section 7.1.1 the
response of (6)-4-(9)¦-7 to L 6-5-9 giving an ear order score of L = 2,
R 7-4-2
R = 1 was decomposed into a score of 2 for the left ear reported first but 0 for the right ear report first; and 1 for the right ear reported second but 0 for the left ear reported second. Similarly, in example (b)
the response of (2)-7-2-(6) ¦ -2-5 to L 7-1-5-2 giving an ear order
R 2-4-3-6
score of L = 1 and R = 2 was broken down into a score of 2 for the right ear reported first but 0 for the left ear reported first; and 1 for the left ear reported second but 0 for the right ear reported second. Thus the decomposition of scores for left/right ear reported first and left/right ear reported second proceeded in like manner. A check was provided in the arithmetic in that the sum of scores for left ear first and left

ear second for any one set of 5 series should equal the set total left ear order score while the sum of right ear first and right ear second scores for the same set should equal the total right ear order score for that set. Table 7-2 shows the relevant descriptive statistics.

Table 7-2

Means (M) and Standard Deviations (SD) of Left/Right Ear Scores for Two Groups (N=58 in each Group) and Left/Right Reported First and Reported Second

Group		Left/Right Reported First		Left/Right Reported Second	
		Left	Right	Left	Right
Experimental (EX)	M	11.67	15.50	5.59	4.60
	SD	6.08	7.38	3.61	2.91
Control (CO)	M	10.83	18.10	7.97	6.10
	SD	5.56	6.35	3.67	3.34

The relatively large spread in respect to the means in both groups may be noticed, thus pointing to wide individual variations. Two separate two-way repeated measures ANOVA were carried out, one for left/right half-spans reported first and the other for left/right half-spans reported second. In both analyses left/right half-span was the repeated measure. In the ANOVA for left/right ear reported first the main effect of right versus left ear is highly significant in favour of the former ($F = 25.138$, $p < 0.001$ for 1/114 df) while the group main effect with an F-ratio of 3.878 for 1/114 df gives a probability of 0.051. In the ANOVA for left/right ear reported second both the group and laterality main effects are highly significant ($F = 19.295$ and $p < 0.001$ and $F = 9.667$, $p = 0.0024$ for 1/114 df respectively). These results are illustrated in Figure 7-2. The slightly lower left ear mean score of 10.83 for the Control Group as compared with 11.67 for the Experimental Group with the left/right half-spans recalled first scoring probably compensates to some extent for the large divergence of 18.10 for the Control Group and 15.50 for the Experimental Group for the right-ear mean score reported first. This explains why the group mean effect borders on significance at the usual level.

Following Inglis and Sykes (1967), the aim of these two related ANOVA was to assess the relative importance of perceptual and memorial processes. If ear-asymmetry is the more potent influence, the main difference in recall accuracy should depend upon whether the digits reproduced have been delivered to the right ear or to the left ear (disregarding recall sequence) with larger right-ear superiority. When the results are graphed, the slopes showing right over left scores are more accentuated in favour of right ear scores. If, on the other hand, memory has the more powerful influence then the right/left difference score will be smaller and the main difference in accuracy of report should lie between stimuli recalled first as compared with stimuli recalled second in sequences, regardless of laterality of recall. The resultant graphs of right over left scores are relatively flat and are less divergent. Unlike Inglis and Sykes who suggest order of recall rather than laterality as the main source of differential accuracy of reporting of dichotic digits in children, the present finding seems to favour the other view. This can be seen from the slope of the 2 top graphs in Figure 7-2 and also from Table 7-1 and Figure 7-1 showing

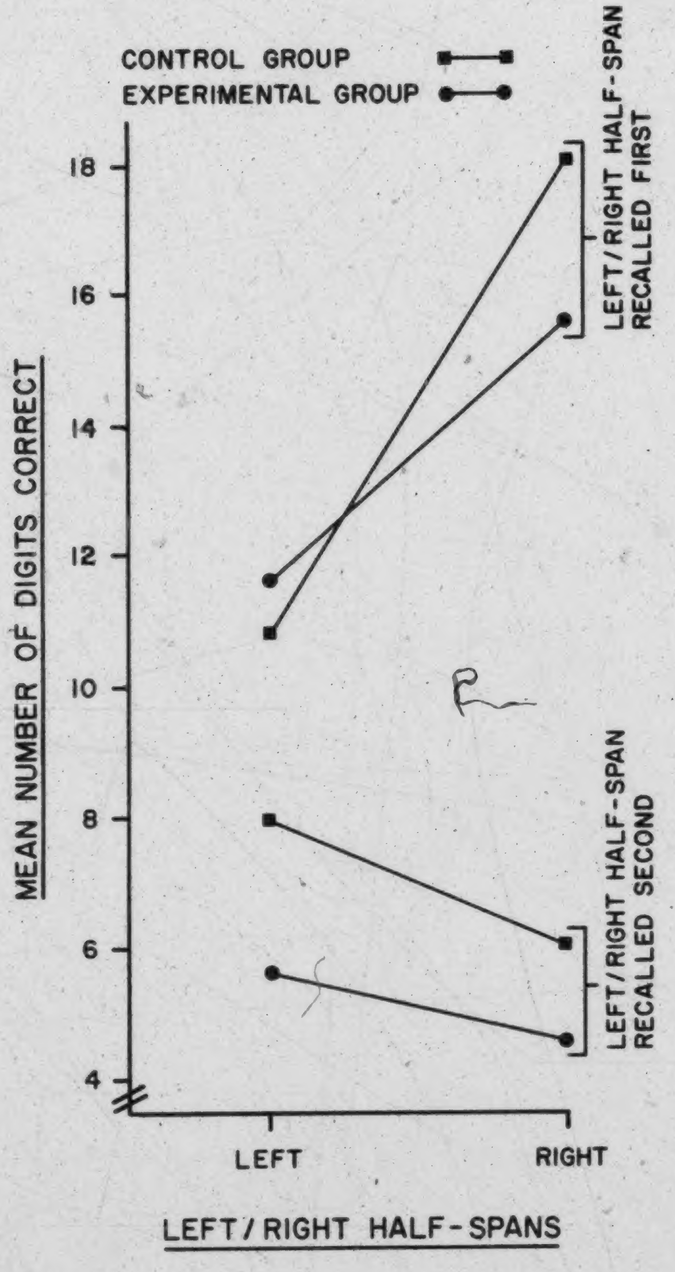

Figure 7-2. Mean number of digits (collapsed across series lengths) correct when both recall and laterality taken into account.

overall right-ear superiority without regard for recall sequence of left/right first or left/right second. Interpretation of the bottom two graphs in Figure 7-2 is probably masked as scores for left/right half-spans recalled second are a function or a residue of left/right half-spans recalled first. The Inglis and Sykes finding is almost certainly flawed by the ceiling effect of the 1-digit, 2-digit and to some extent 3-digit pairs for the 6 age groups from 5 to 10 years as can be deduced from their relatively flat graphs and from the results of their correlated "t" tests. A more serious methodological problem which must have eluded Inglis and Sykes and which the present two analyses partly share is the effect of intrusion of stop consonants and vowels, not to mention lag effect, on both perceptual and memorial process (Section 5.3).

Thus the Inglis and Sykes claim of supremacy of memory over ear asymmetry is not proven. Satz and associates (Bartz, Satz, Fennell, and Lally, 1967; Satz, Achenbach, Pattishall, and Fennell, 1965) have suggested a rapprochement of the ear asymmetry findings and the Broadbent model. Given the much improved, though less than perfect, instrumentation of the present study, the suggestion made earlier of greater relative importance of perceptual processes vis-a-vis memorial ones must be interpreted with some caution. Further indirect reference will be made in the section dealing with Hypothesis 4 in Dichotic Listening Experiments 2 and 3. A less unequivocal answer to the equivocal question of contribution of perception and memory may be forthcoming when there is even more refined stimulus control such as onset synchrony, the equating of acoustic elements and environments.

7.2.3 Hypothesis 3--Lateralization Effect for Group, Half-Span and Series Length

The hypothesis to be tested was the expected significance of the main effects of group (Experimental and Control), half-span (left and right ears) and series length (2-digit, 3-digit, and 4-digit pairs) and the influence of two methods of report by ear order and attempted ear order. The appropriate statistical technique used was the 2 group (A) x 2 half-span (B) x 3 series length (C) analysis of variance (ANOVA) with the last two factors B and C repeated. For each order of report two different analyses were carried out: one using total correct scores summed for each set of 5 series and the other using arcsin transformations of the proportions correct for each set. Thus the 4 three-way ANOVA proceeded as follows:

(a) Ear Order Report based on:
  i) Total score for each set of 5 series;
  ii) Arcsin transformation of proportions from (a) i) above;
(b) Attempted Ear Order Report based on:
  i) Total score for each set of 5 series;
  ii) Arcsin transformation of proportions from (b) i) above.

(a) Ear Order Report

Mean scores in respect of (a) i) for group (A1 for Group EX, A2 for Group CO), half-span (B1 for left-ear and B2 for right-ear) and series length (C1 for 2-pair, C2 for 3-pair, C3 for 4-pair) are shown in the ABC summary Table 7-3.

Table 7-3

Ear Order Means for Group (A), Half-Span (B) and Series Length (C)

A	B	C		
		1	2	3
1	1	5.190	5.845	6.207
1	2	5.983	7.069	7.052
2	1	5.707	6.103	6.983
2	2	6.379	8.259	9.569

These results are illustrated graphically in Figure 7-3 which shows the group for group inter-ear differences for the three series lengths. Essentially the same data could be displayed flexibly in Figure 7-4. This shows graphically ear for ear the inter-group differences for the three series lengths. As can be seen in Figure 7-3 the two-digit series for the left and right half-spans difference is less divergent, indicating much less discrimination than the other series lengths. The right-left difference is the largest for both groups for the three-digit series for the Experimental Group but the relative distance is maintained for the Control Group. This probably indicates the less "limited capacity" for the latter group in respect of memorizing and chunking 4 digits in each ear simultaneously or 8 digits in both ears. Figure 7-4 shows the general superiority of the right ear over the left ear for each group.

A three-factor ANOVA with B and C repeated shows all the main effects are significant (for A, F = 14.84, 1/114 df, $p < 0.001$; for B, F = 26.39, 1/114 df, $p < 0.001$ and for C, F = 56.77, 2/228 df, $p < 0.001$).

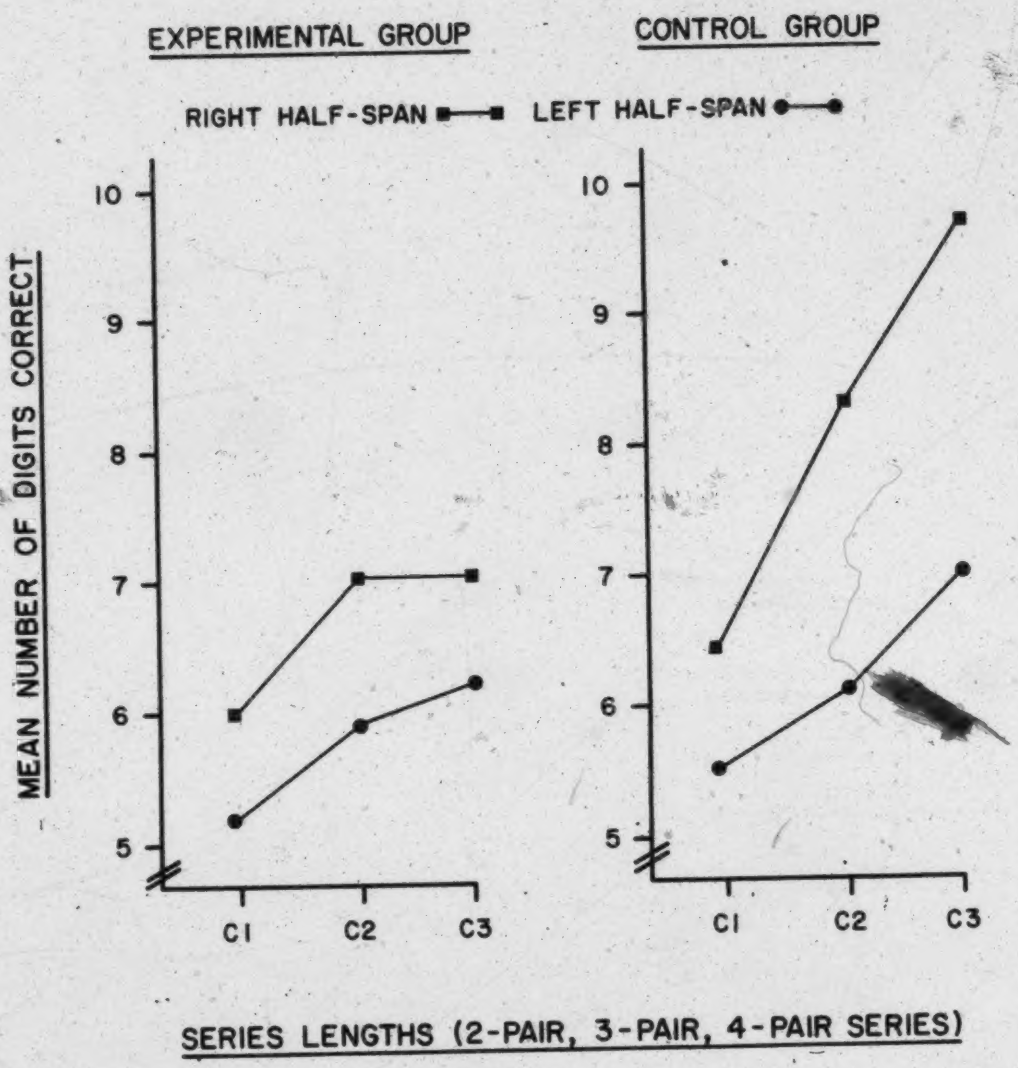

Figure 7-3. Ear order group for group inter-ear mean scores for varying series lengths.

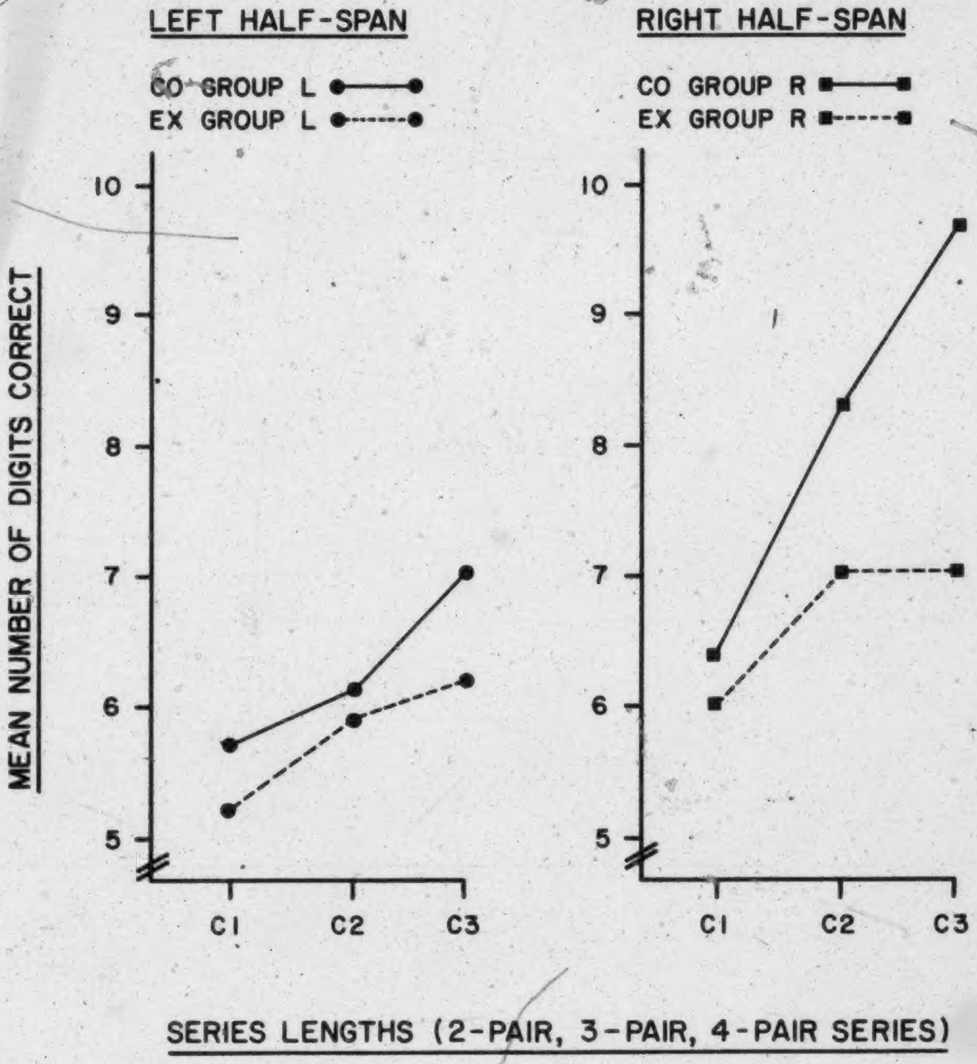

Figure 7-4. Ear order ear for ear inter-group mean scores for varying series lengths.

Of the two-way interactions AB is not significant (F = 2.51, 1/114 df, p = 0.1160) while both group x series length (AC) and half-span x series length (BC) are significant (for AC, F = 8.11, 2/228 df, p = 0.00040; for BC, F = 4.44, 2/228 df, p = 0.0128). ABC interaction is also significant at the 0.05 level (F = 3.09, 2/228 df, p = 0.0476). The significant AC, BC and ABC interaction effects raise some interesting points which will be taken up presently. To some extent this could be a measure of the nonadditivity of the main effects. It could more likely be due to the scale of measurement. To better understand the interaction phenomenon, simple effects were analysed. These are shown graphically in Figure 7-5.

For all the three graphs the lines do not cross. This ordinal interaction makes possible the interpretation of main effects which are identical with that made in the additive statistical model used (Bracht and Glass, 1968; Lubin, 1961). In the case of group (A) for each half-span level of (B) the distance between the right ear scores is greater than that for the left ear. When either group or half-span is related to series lengths, it can be seen the 2-pair series give minimal discrimination while the 4-pair series seem to magnify the difference and the 3-pair series give the more stabilizing results.

To further clarify the meaning of interaction effects from the above, a second three-factor repeated measures ANOVA was carried out with the same data but using arcsin transformation of the proportions ((a)ii)). The result is clear-cut. Table 7-4 shows the ear order means transformed for the two groups, two half-spans and three series lengths.

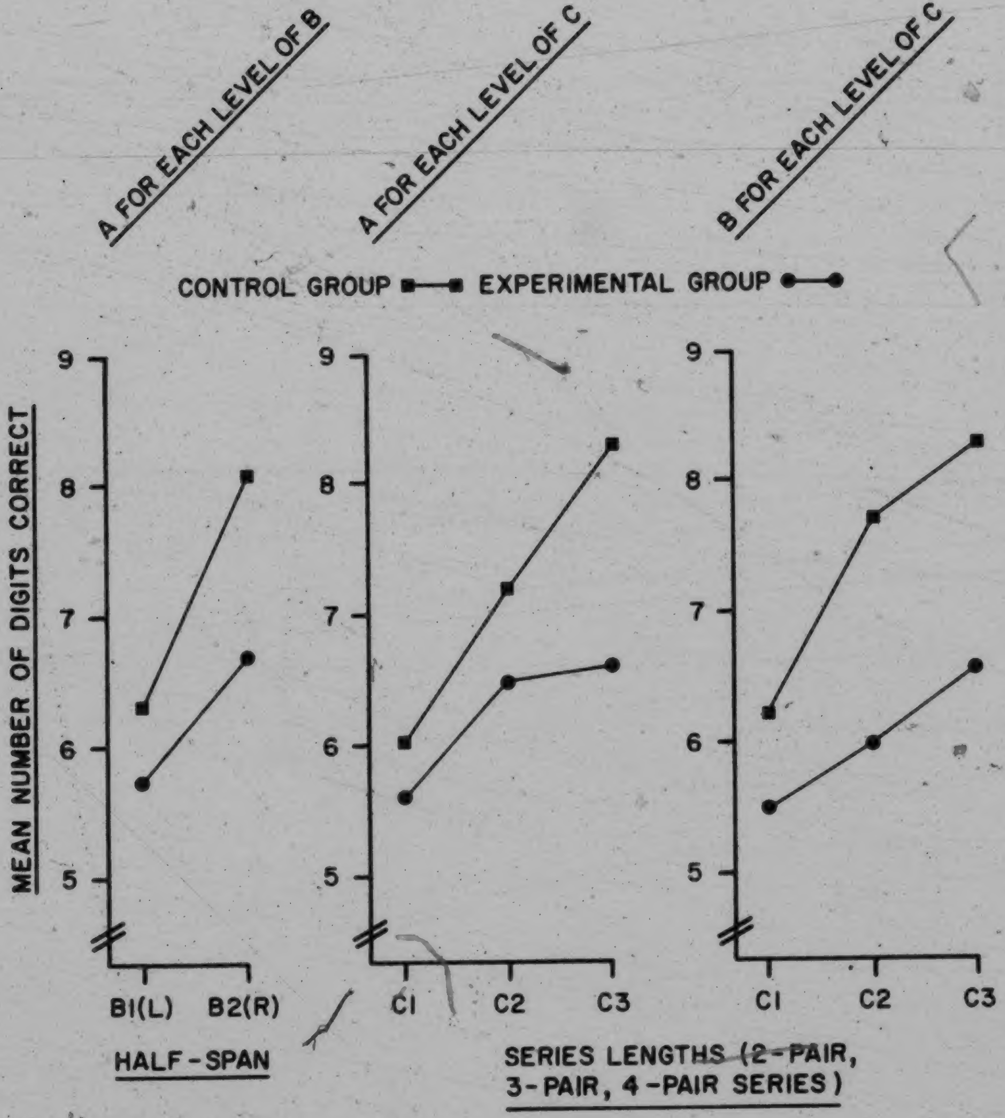

Figure 7-5. Ear order two-way interaction simple effects.

Table 7-4

Ear Order Means (Arcsin) for Group (A), Half-Span (B) and Series Length (C)

A	B	C		
		1	2	3
1	1	1.618	1.335	1.148
1	2	1.795	1.513	1.285
2	1	1.746	1.370	1.251
2	2	1.889	1.673	1.529

In the three-way repeated measures ANOVA for group (A), half-span (B) and series length (C) with B and C repeated, only the main effects of group, half-span and series length are significant (for group F = 10.35, 1/114 df, p = 0.0017; for half-span F = 26.49, 1/114 df, p < 0.001; for series length F = 132.10, 2/228 df, p < 0.001). None of the interaction effects are significant. For clearer interpretation the arcsin transformations were reverted to proportions before graphing.

Figure 7-6 shows essentially the same information as in Figure 7-3 while Figure 7-7 that in Figure 7-4. Once again the 3-digit and 4-digit series are more discriminating and the Control Group shows relatively greater divergence between the two half-spans. It may be pointed out that in order to achieve comparability and exactitude in transforming the individual set proportions into arcsin for ANOVA for easier visual identification in the graphs of Figure 7-6 and 7-7, some finer discrimination can be lost. Nevertheless, the corresponding figures complement each other and provide more meaningful interpretation.

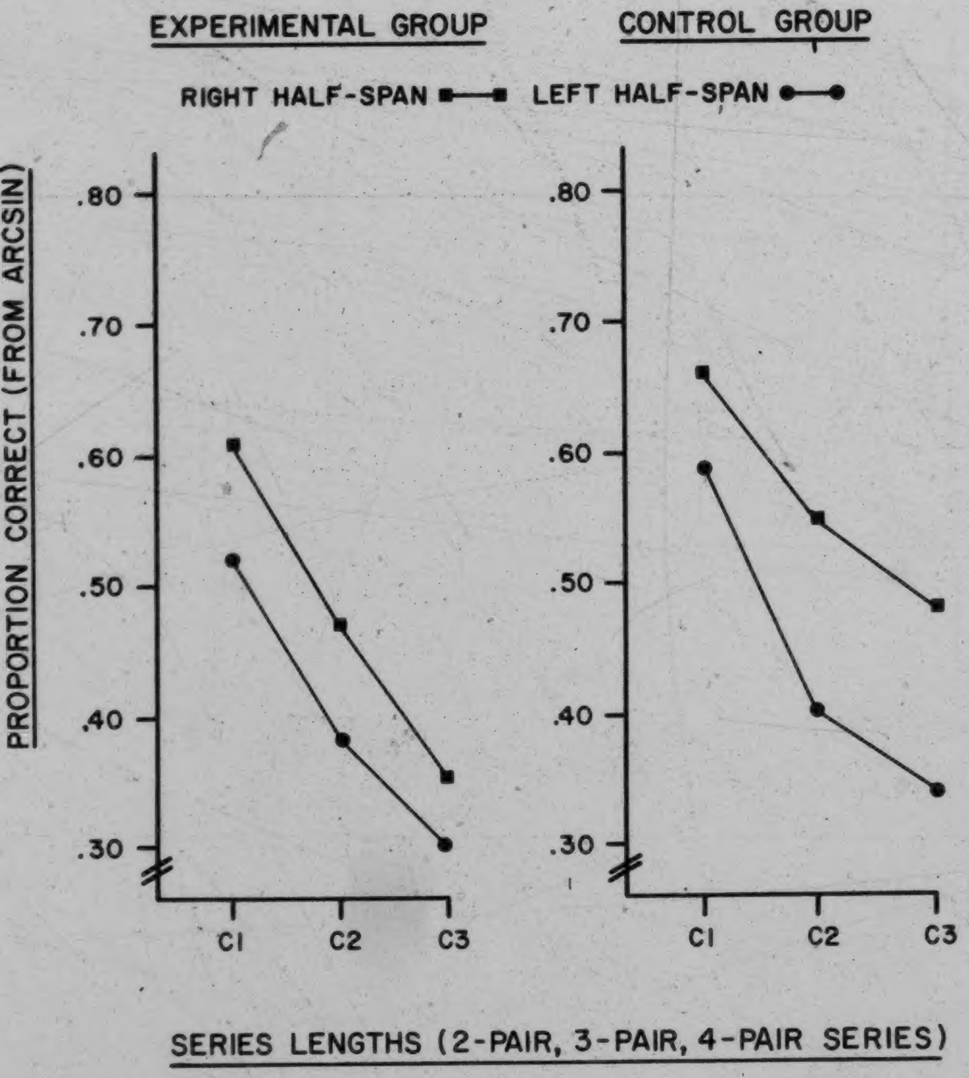

Figure 7-6. Ear order group for group inter-ear mean proportions (from arcsin transformations) for varying series lengths.

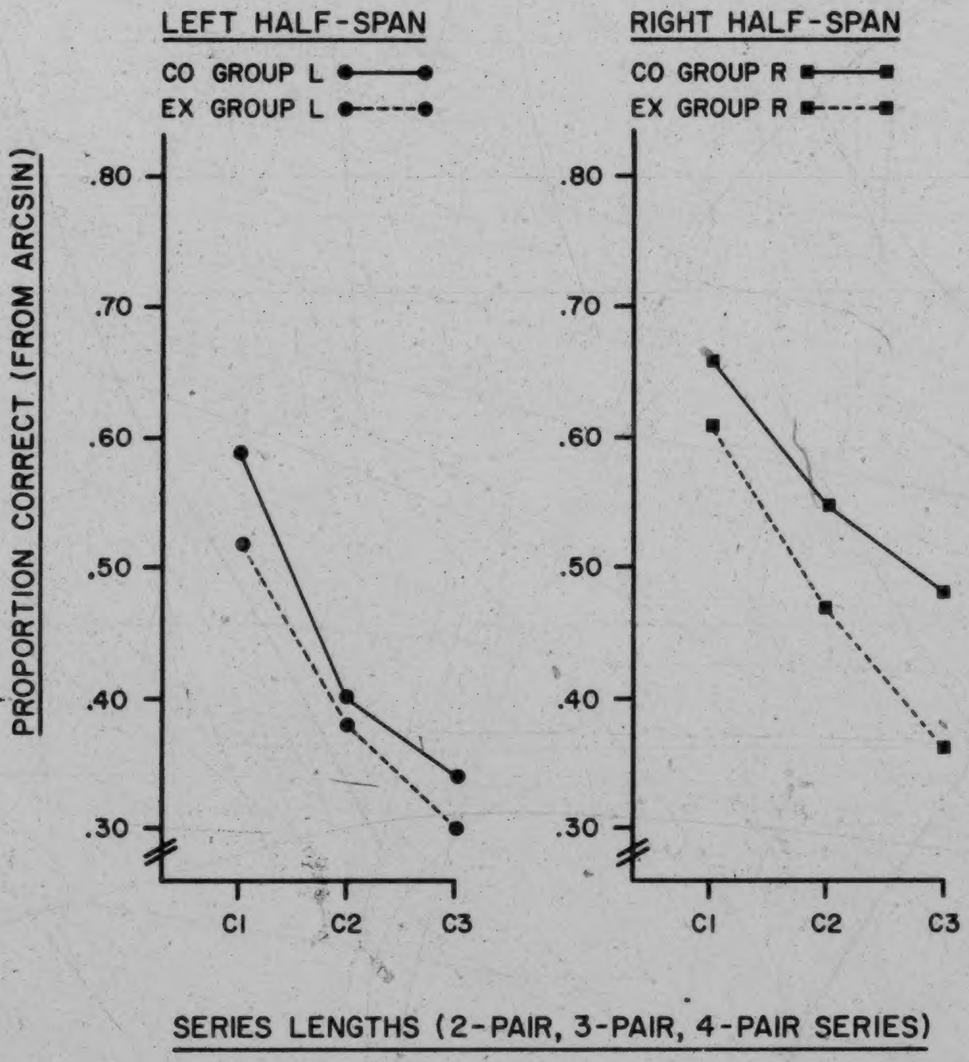

Figure 7-7. Ear order ear for ear inter-group mean proportions (from arcsin transformations) for varying series lengths.

In evaluating the complementary results of (a)i) and (a)ii) for ear order, it was decided to give greater weight to those obtained from the simplest additive model ((a)ii) with arcsin transformation) as providing the more complete and adequate summary of the experimental data (Winer, 1962, p. 148). Thus Hypothesis 3 is upheld in respect of the ear order reporting.

(b) Attempted Ear Order Report

Mean Scores for attempted ear order reporting using total scores and arcsin transformations of proportions as in (a) ii) are shown side by side in Table 7-5.

Table 7-5

Attempted Ear Order Means and Means for Arcsin
for Group (A), Half-Span (B) and Series Length (C)

		From Total Scores			From Arcsin		
A	B	C			C		
		1	2	3	1	2	3
1	1	7.483	8.741	9.440	2.176	1.750	1.524
1	2	8.690	10.552	10.664	2.536	2.020	1.662
2	1	8.586	10.043	11.345	2.526	1.932	1.722
2	2	9.552	11.819	12.690	2.870	2.209	1.873

The attempted ear order mean total scores are graphed in Figure 7-8 and Figure 7-9. Generally the group for group inter-ear differential is relatively larger for the Experimental Group than for the Control Group, probably showing the more heterogeneous performance of the former. Overall, the 3-digit pairs series seem to be more discriminating as confirmed by inspection of the data which show the set of 2-digit pair series did not provide sufficient ceiling for both groups and the 4-digit pair series sufficient floor for the Experimental Group. Similar information conveyed in Figure 7-8 and in Figure 7-9 is shown in the corresponding Figures 7-10 and 7-11, except mean proportions from arcsin transformations rather than mean number of digits are portrayed in these last two graphs. As with the mean proportion graphs for ear order reporting some finer discrimination could be lost in graphing the results of Figure 7-8 onto Figure 7-10 and corresponding Figure 7-9 onto Figure 7-11. Nevertheless, the total information conveyed is made clearer.

Two separate group x half-span x series length repeated measures ANOVA were carried out, one using attempted ear total scores and the other using attempted ear arcsin transformations. In both analyses half-span and series length were the repeated factors. Once again the main effects are highly significant. With attempted ear total scores the F-ratio for group = 36.07, 1/114 df, $p < 0.001$; for half-span F = 39.01, 1/114 df, $p < 0.001$; for series length F = 164.23, 2/228 df, $p < 0.001$. With attempted ear arcsin scores the F-ratio for group = 36.89, 1/114 df, $p < 0.001$; for half span F = 44.52, 1/114 df, $p < 0.001$; for series length F = 596.10, 2/228 df, $p < 0.001$. The two-way interactions group x series

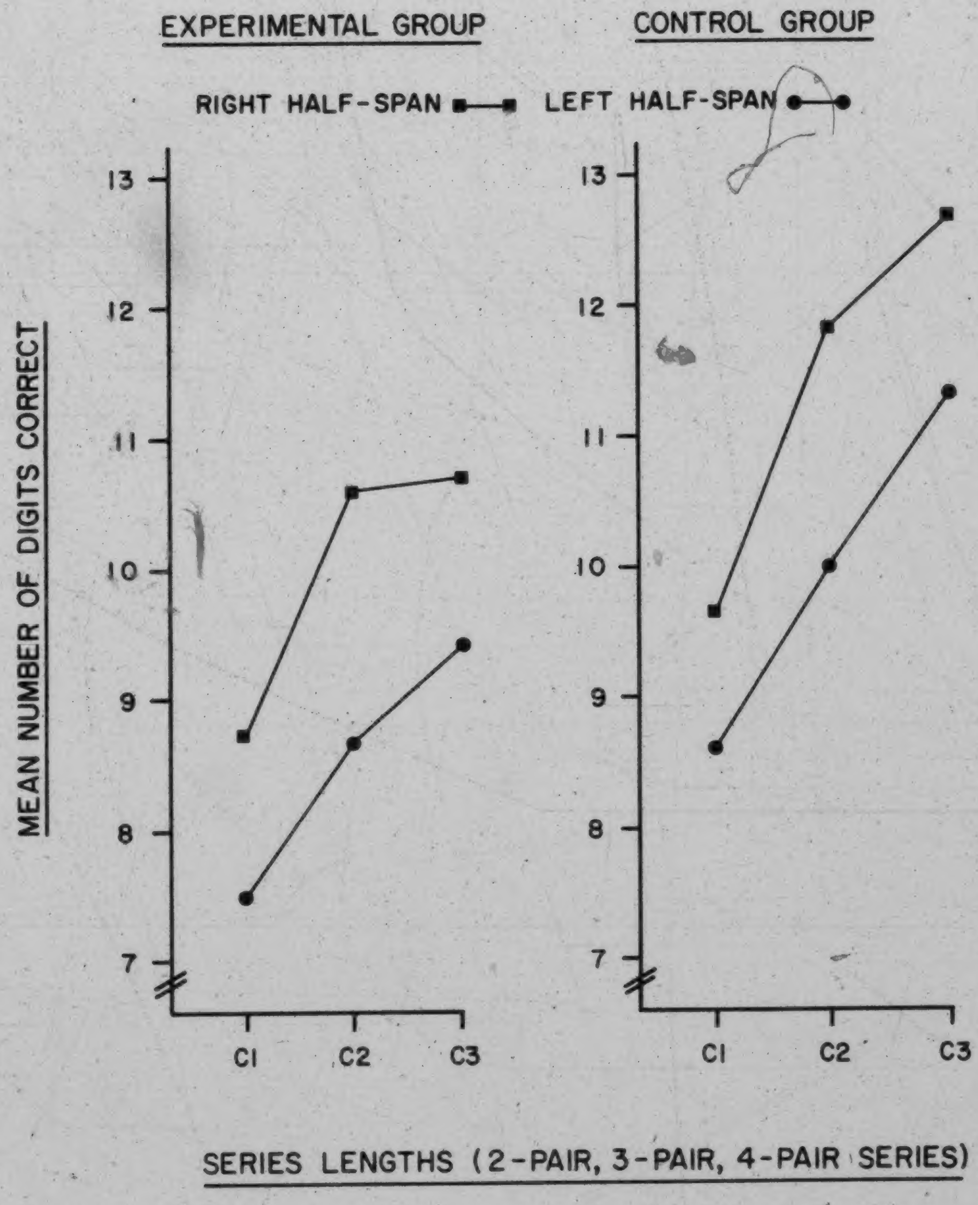

Figure 7-8. Attempted ear order group for group inter-ear mean scores for varying series lengths.

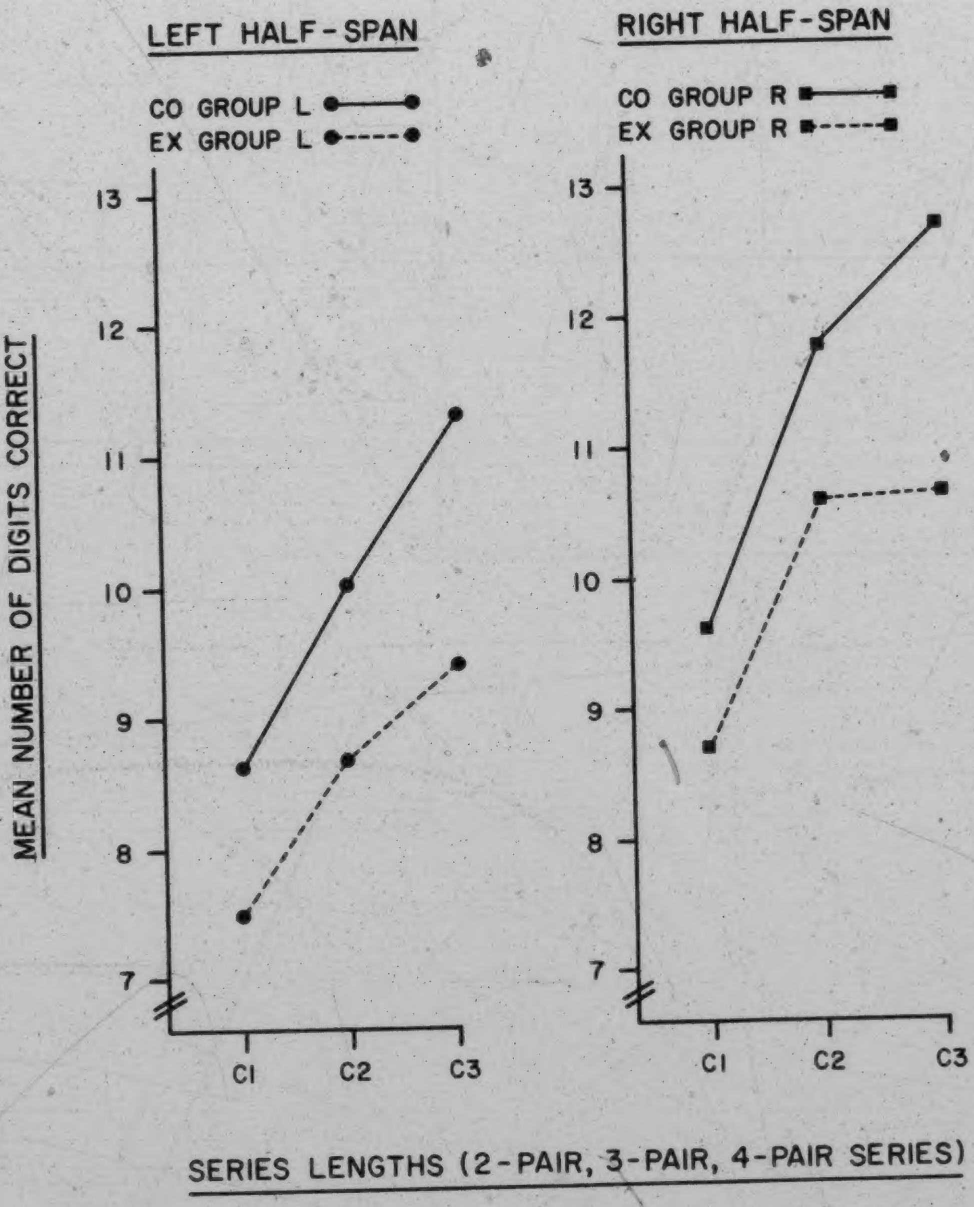

Figure 7-9. Attempted ear order ear for ear inter-group mean scores for varying series lengths.

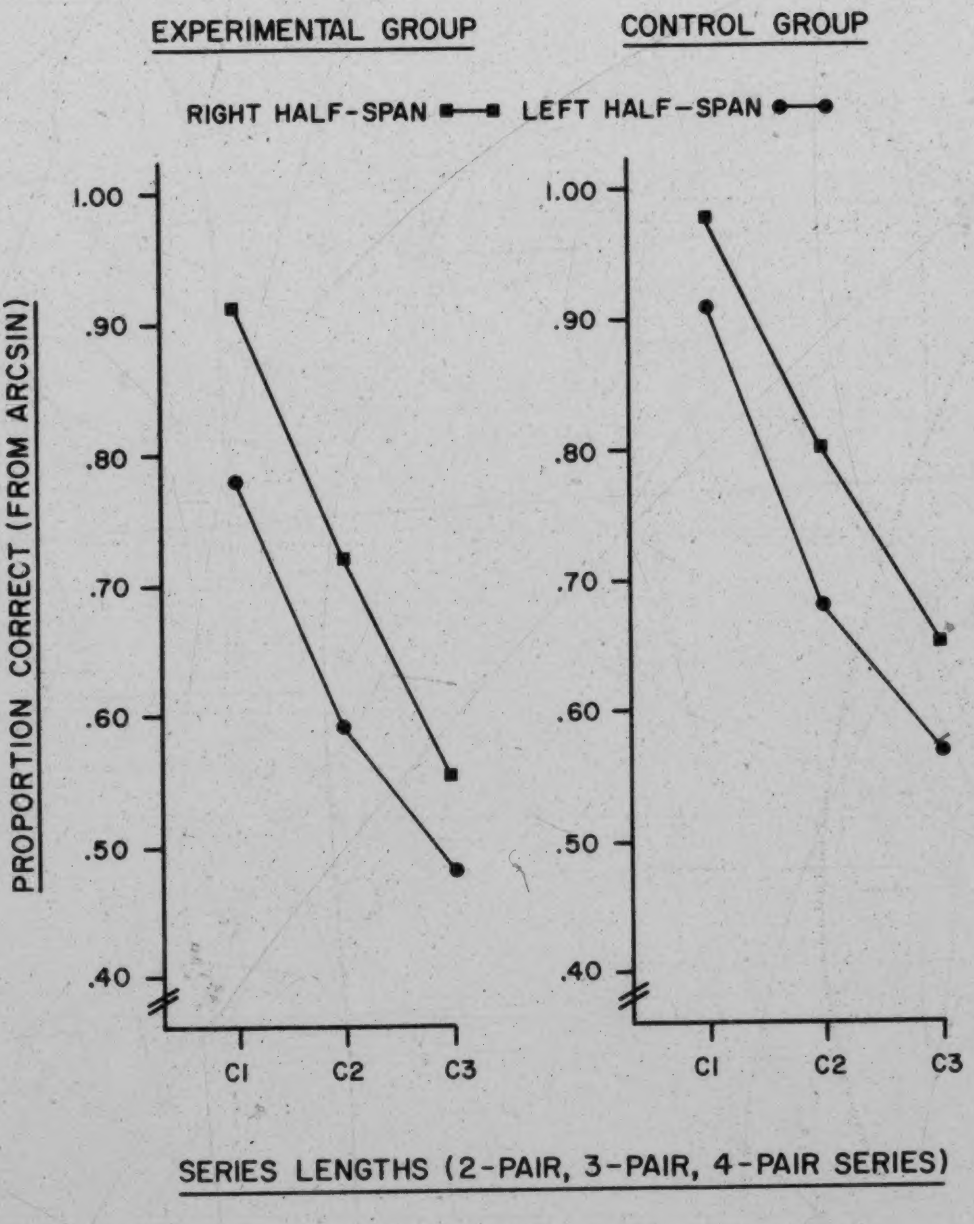

Figure 7-10. Attempted ear order group for group inter-ear mean proportions (from arcsin transformations) for varying series lengths.

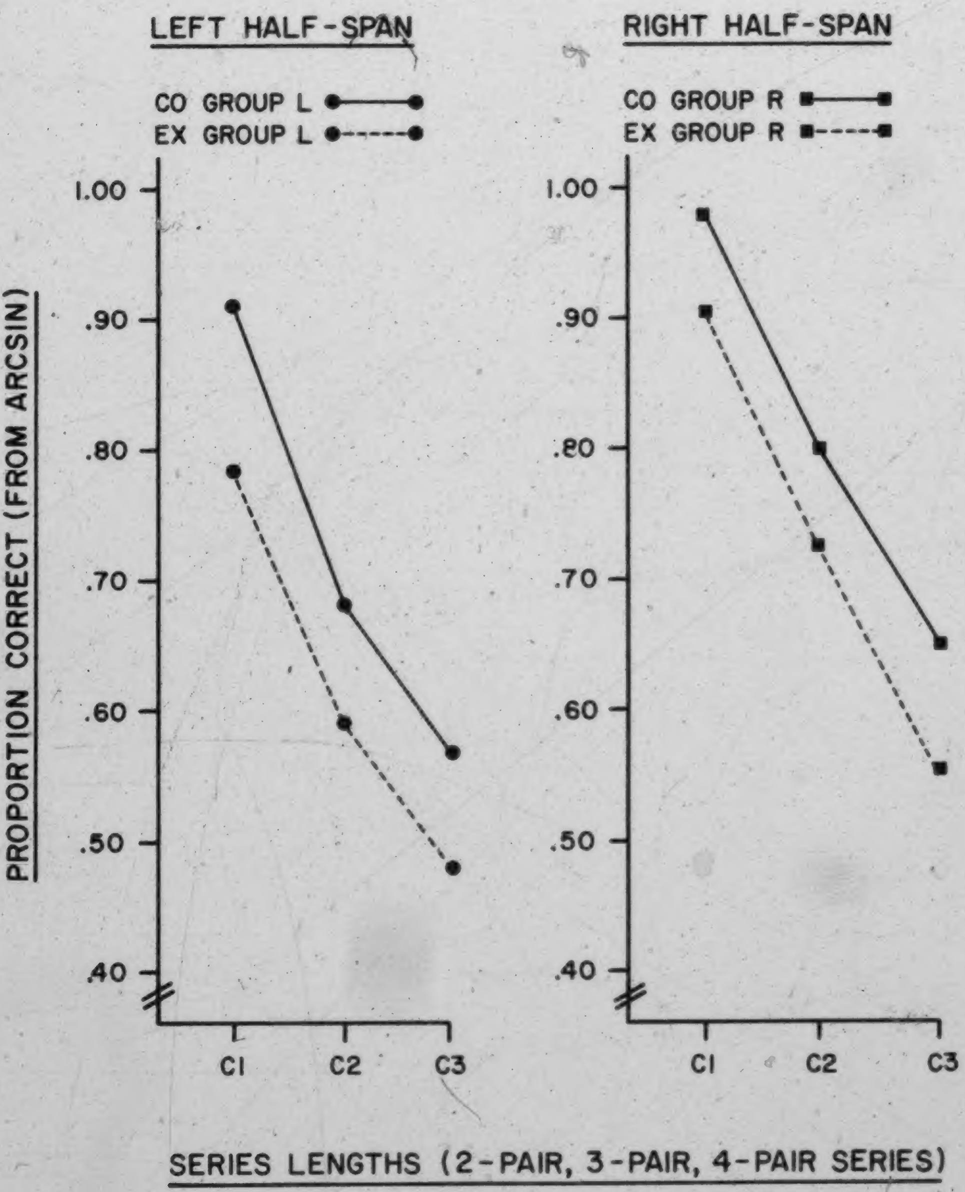

Figure 7-11. Attempted ear order ear for ear inter-group mean proportions (from arcsin transformations) for varying series lengths.

length (AC) is found to be significant with the attempted ear total score (F = 6.55, 2/228 df, p = 0.0017) and with the attempted ear arcsin scores (F = 6.07, 2/228 df, p = 0.0027). With the latter scores the ear x series length (BC) is also found significant (F = 6.11, 2/228 df, p = 0.0026).

To explain the interaction effects analyses of simple effects were carried out (Lubin, 1961; Winer, 1962) as done previously with the ear order reporting. In view of the non-disappearance of significant interaction effects with arcsin transformed scores, more detailed analyses involving two-way and three-way simple effects were carried out with these attempted ear order scores. Figure 7-12 shows the two-way simple effects and should be compared with the corresponding ear order analysis graphed in Figure 7-5. As with the earlier illustration the lines in the three graphs do not cross and this ordinal interaction still makes main effects statements meaningful. With the first group (A for each level of B) the two lines have the same shape (i.e., are parallel) and hence the AB interaction effects are zero. This is a graphic verification of the ANOVA results with the attempted ear arcsin transformations. From careful inspection of the data and the other graphs it is possible that series lengths of median difficulty providing for the best discrimination will likely remove the interaction effects. This would occur with a concentration of 3-pair items and a smaller proportion of 4-pair items to give more head room to the Control Group.

The molar three-way interaction effect of group (2 levels) x half-span (2 levels) x series length (3 levels) is shown graphically in Figure 7-13. Group for group and half-span for half-span the lines are

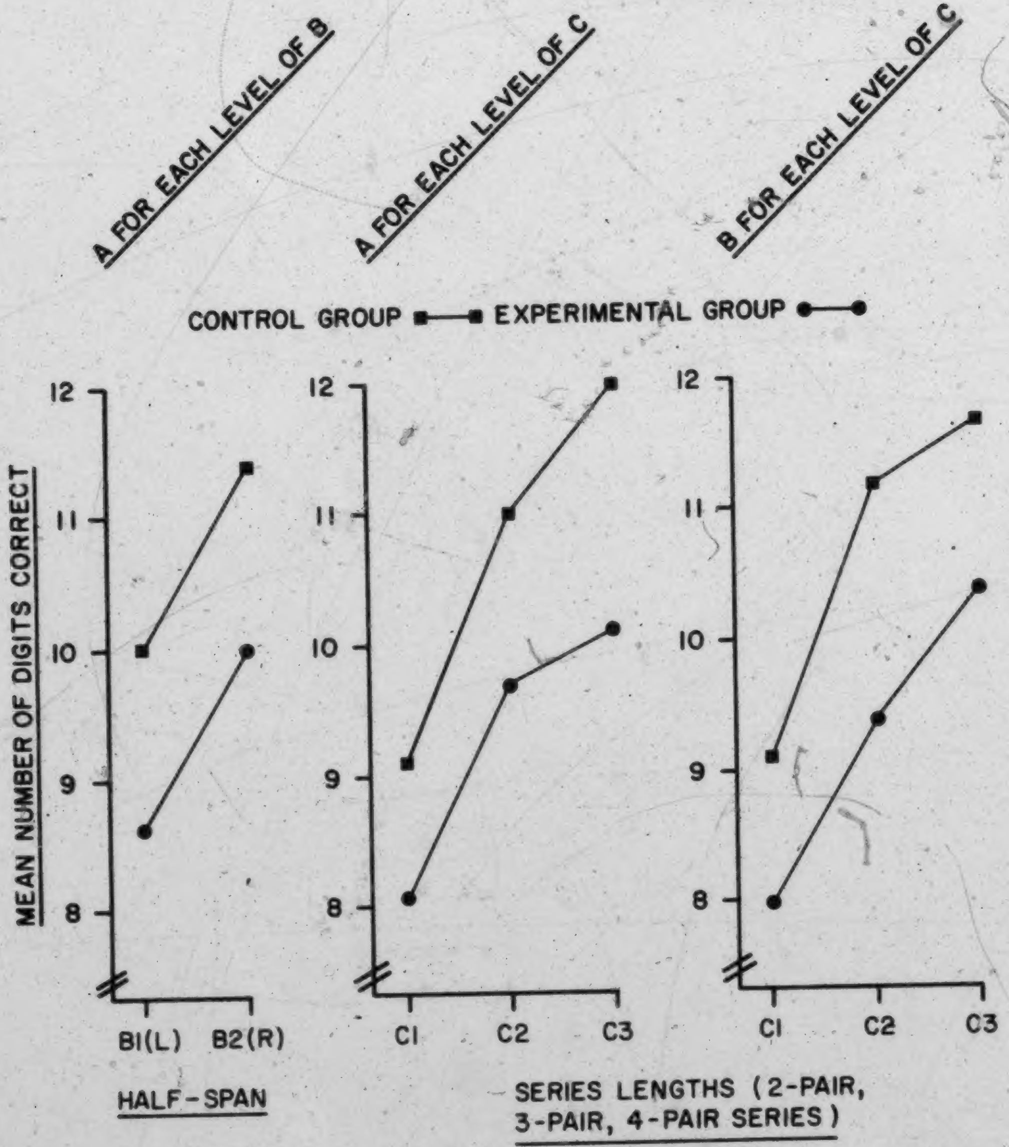

Figure 7-12. Attempted ear order two-way interaction simple effects.

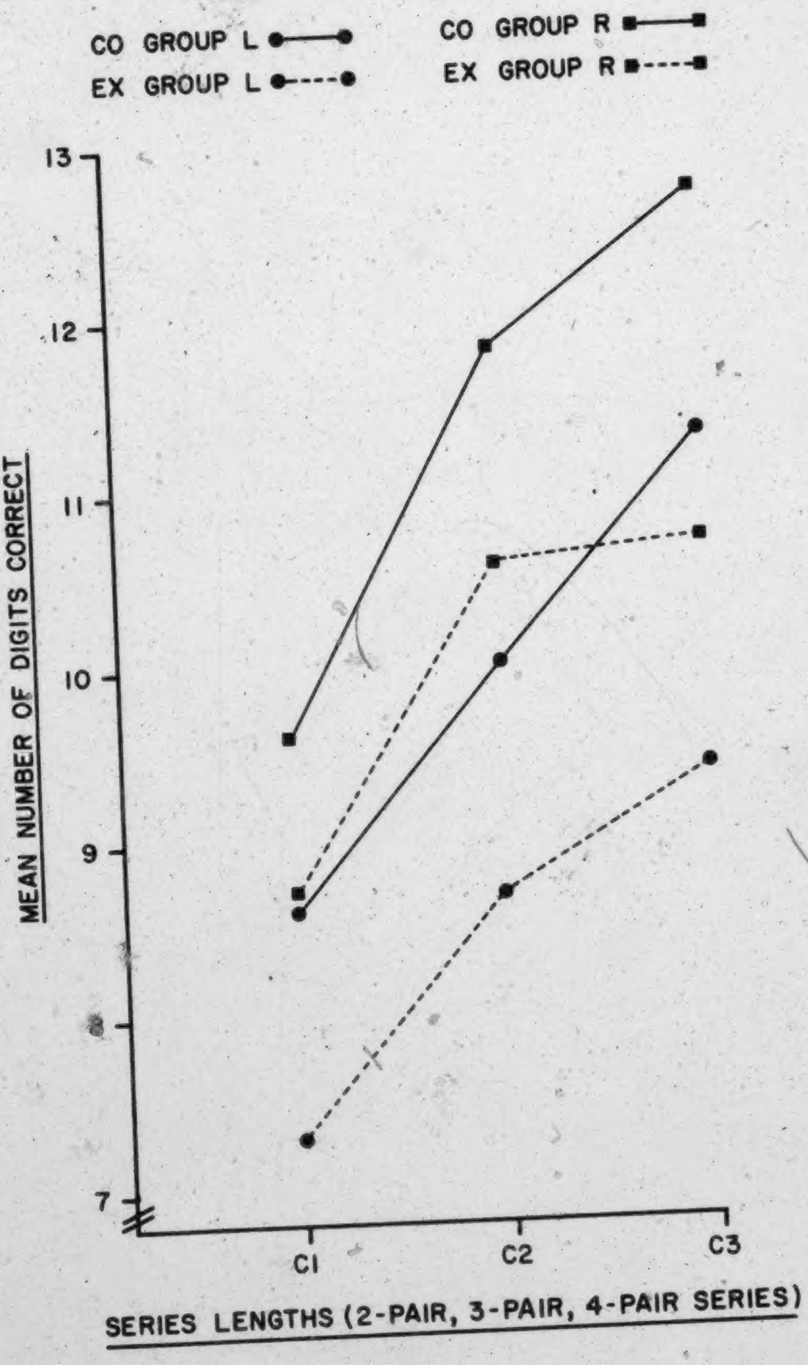

Figure 7-13. Attempted ear order group (A) by half-span (B) by series length (C) three-way interaction effects.

of similar shapes except for the slight tapering for the 2-pair series and the slight divergence for the 3-pair series for the Experimental Group. This divergence should be read in conjunction with Figure 7-8. The molecular three-way interaction effects were studied via three separate analyses.

Figure 7-14 shows the Group (A) x Half-Span (B) for Levels of Series Length (C's) three-way interaction simple effects. It is interesting that the profiles are of the same shape. The lines of the graphs for each of the levels of C1, C2 and C3 are parallel and the lines are also geometrically similar to those for the combined C's. Hence the interaction is zero (Winer, 1962, p. 181). In other words, series length for series length there is no significant group x half-span interaction. Figure 7-14 gives a more analytic geometric representation of the left-most graph in Figure 7-12 and reinforces it.

Figure 7-15 shows the half-span (B) by series length (C) for levels of group (A's) three-way interaction simple effects. This should be read in conjunction with the more vivid portrayal in Figure 7-16. This latter figure displays the group (A) x series length (C) for levels of half-span (B's) three-way interaction simple effects.

The profiles in Figure 7-16 are of the same shape up to the 3-pair series and diverge with the 4-pair series. As remarked earlier, maximal discrimination is probably provided by series of median difficulty and this occurs mostly with the 3-pair series. The 4-pair series, while providing more room for the Control Group, also expands the distance separating the two groups and hence attentuates the force with which statements about the main effects can be made.

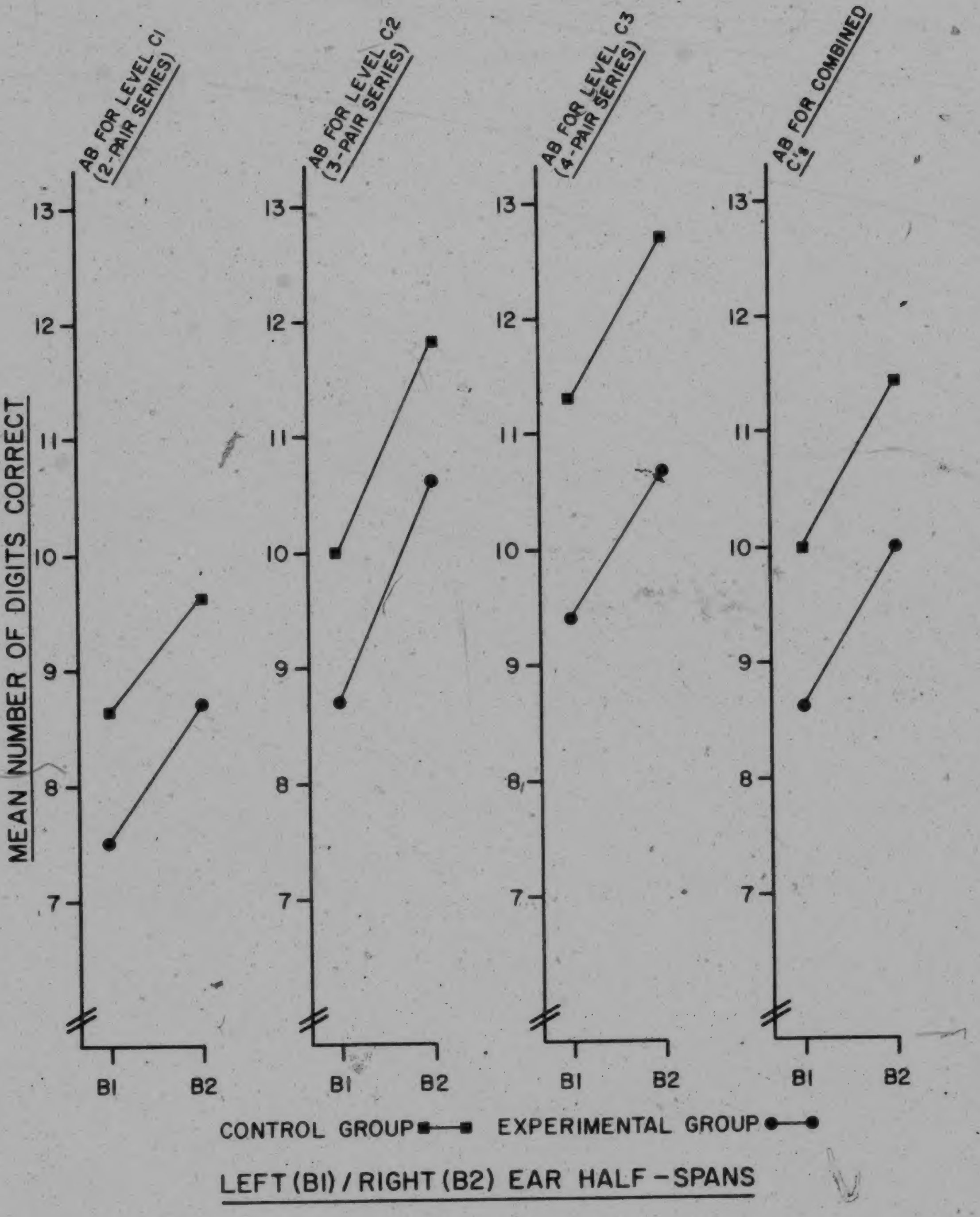

Figure 7-14. Attempted ear order group (A) by half-span (B) for levels of series length (C's) three-way interaction simple effects.

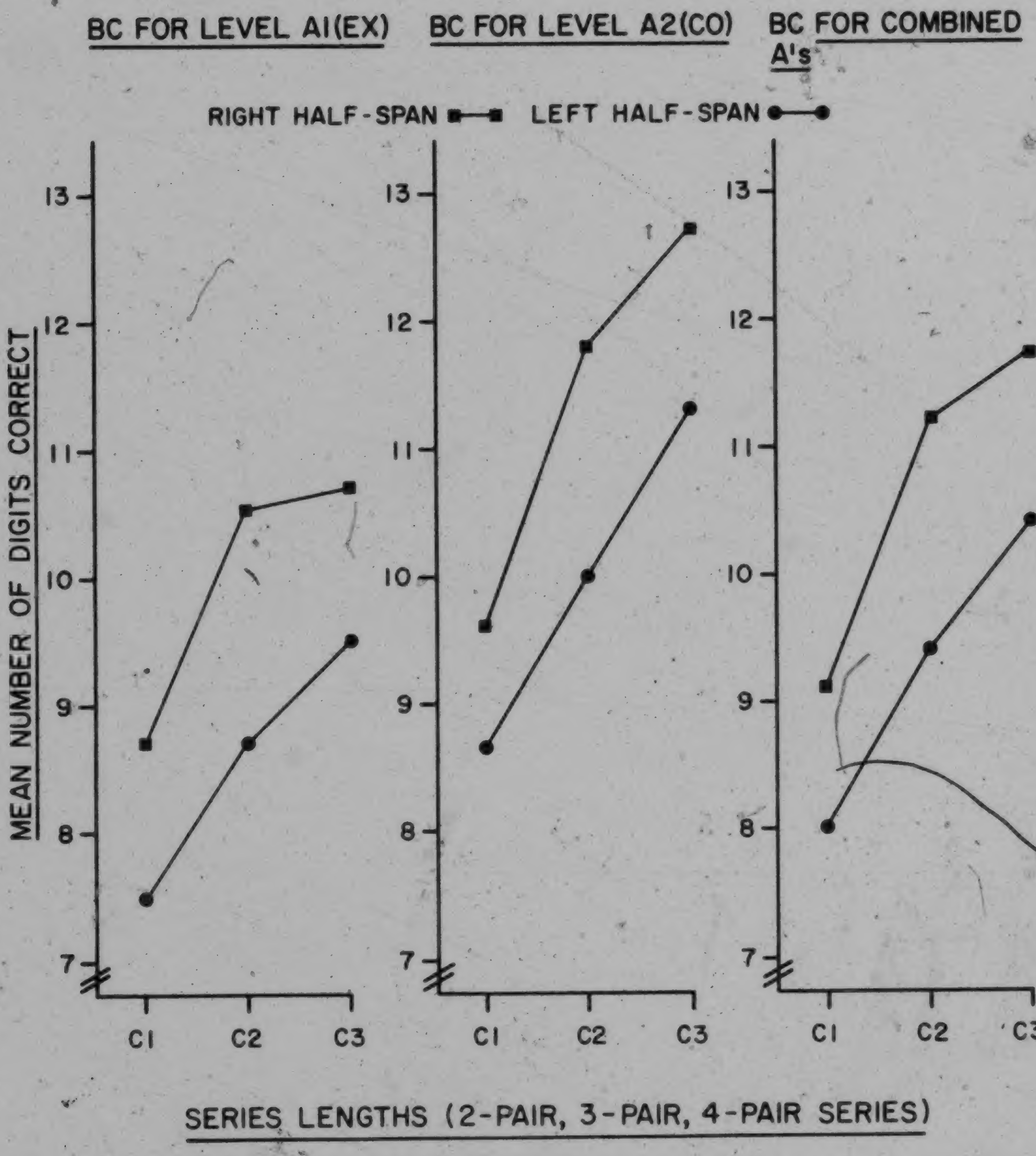

Figure 7-15. Attempted ear order half-span (B) by series length (C) for levels of group (A's) three-way interaction simple effects.

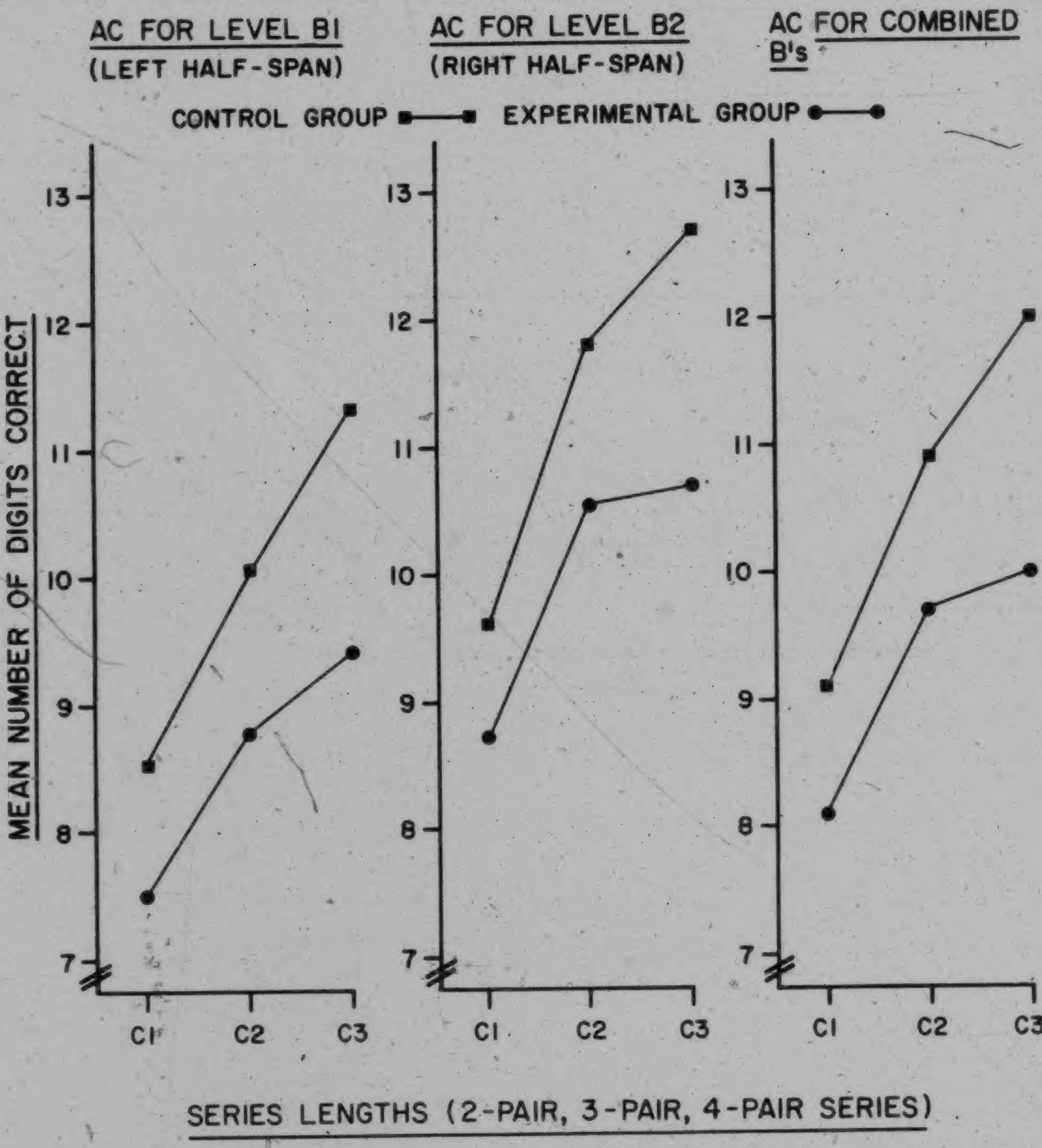

Figure 7-16. Attempted ear order group (A) by series length (C) for levels of half-span (B's) three-way interaction simple effects.

To recapitulate what has been said of the testing of Hypothesis 3 in studying group, half-span and series length effects: separate three-factor repeated measures ANOVA were carried out with both ear order and attempted ear order reporting. Each category of report was also scored according to total scores for each set of 5 series and to arcsin transformations of proportions for non-additivity effect or for the removal of interactions. With these analyses homogeneity of covariance is more likely to occur and hence homogeneity of variance-covariance is not tested as the correlations between the repeated levels of half-span and of series length are not "treatment bound", as in typical learning situations. Without exception, all main effects are found to be significant. In other words, the Control Group performs better than the Experimental Group, the right half-span is superior to the left half-span and dichotic performance is related to the lengths of the digit series. Generally the group x half-span effect is not significant and the other interaction effects vary. All obtained interactions are ordinal with no crossing of lines and this permits meaningful interpretation of main effects (Bracht and Glass, 1968; Lubin, 1961; Winer, 1962). From inspection of both the data and the geometric representations it is shown that the four-pair series probably contribute to more of the variation. This raises at least two points. One point relates to the justification of the writer's modification of dichotic digit lists as used by Inglis and Caird (1963), by Neufeldt (1966); and in using series lengths of 2-digit, 3-digit and 4-digit pairs (Section 6.3) as being consonant with the memory span of the magical number of 7 ± 2 (Miller, 1956). The other point brings up the important question of attempting to explain how interactions occur or how they can be brought under control. The results show that series lengths of median difficulty may bring about the desired additivity effects.

7.3 Results and Discussions of Dichotic Experiments 2 and 3

The rationale of Dichotic Listening Experiments 2 and 3 can be stated simply in the following terms. When dichotic information is presented at a fast rate the Broadbent (1958) attention hypothesis suggests the image of a filter which selects a channel or a modality, stays on that channel until the termination of its message and then switches to accept the second message which has been waiting in store in the S-System (Figure 5-1). This is claimed to be the best recall strategy for the subject. Subsequent workers, however, have shown that the report of dichotic items by channel can be overcome by other grouping factors. This was first shown by Gray and Wedderburn (1960). They presented the segmented syllables of a word (e.g., ex-tir-pate) or the three words of a short phrase (e.g., mice-eat-cheese) in alternation between the two ears (e.g., right-left-right) and simultaneously alternating a list of three digits (left-right-left). They found that subjects' report followed the content of the stimuli rather than the ear of arrival. Similar "tag" effects have been shown by Bartz, Satz, and Fennell (1967). Broadbent and Gregory (1964), Yntema and Trask (1963). With the present Dichotic Listening Experiment 2 the children were pre-instructed to use the sides strategy in a counter-balanced order to report the stimuli (left ear first then right ear or vice versa). In Dichotic Listening Experiment 3 they were pre-instructed to use the types strategy (digits first then letters or vice versa). Thus in considering these two experiments together and in comparing their results some insight is afforded into the use the children make of strategies in processing information.

7.3.1 Hypothesis 4--Recall Strategies by Sides and Types

In attempting to evaluate Hypothesis 4 of the differential use of strategies in the recall of dichotic digits and letters both the serial scoring according to correct elements reported in the exact positions and free scoring according to only correct elements were used. Table 7-6 shows the mean scores for each of the two recall strategies for each method of scoring.

Table 7-6

Means (M) and Standard Deviations (SD) for Two Groups (N=58 in each Group) as a Function of Strategies for Two Methods of Scoring

		Serial Scoring		Free Scoring	
Group		Sides	Types	Sides	Types
Experimental (EX)	M	24.84	24.93	36.24	35.12
	SD	8.86	6.78	6.96	6.76
Control (CO)	M	34.91	38.21	43.88	44.17
	SD	10.16	7.87	7.87	6.76

This information is shown in the histograms in Figure 7-17. For the more stringent serial scoring it is interesting to note that disabled readers seem not to be able to use differential strategies as shown by the almost identical mean sides and types scores of 24.84 and 24.93, although the SD's differ slightly. For the Control Group, however, the "tag" effect must have taken place as evidenced by the higher mean scores for the types recall. In other words, the group resorts to the strategy of reporting elements with contents as instructed (digits/letters) rather than the more "natural" sides reported. It should be noted, however, this tag advantage is lost (with the Control Group) with free scoring which is less discriminating than serial scoring. The results shown in Figure 7-17 should be interpreted in conjunction with the two group (A) x strategies (B) repeated measures ANOVA with the latter repeated. In both analyses (serial scoring and free scoring) the main effects for group are highly significant (for serial scoring $F = 72.496$, 1/114 df, $p < 0.001$; for free scoring $F = 47.729$, 1/114 df, $p < 0.001$). With serial scoring the sides/types strategy is also significant ($F = 4.317$, 1/114 df, $p = 0.03997$) while the interaction hovers round a p of 0.051, whereas with free scoring the strategies effect is not significant. This is not unexpected in view of the more generous nature of free scoring as to make it less discriminating. Thus from the more stringent serial scoring Hypothesis 4 relating to the inefficient use of strategies in processing dichotic materials by disabled readers is upheld.

The findings here may be compared with those of Neufeldt (1966) and Yntema and Trask (1963). With 2 groups of 13 retardates each (organic and cultural-familial) matched with a normal MA group and a normal CA group Neufeldt found no significant difference, except for the

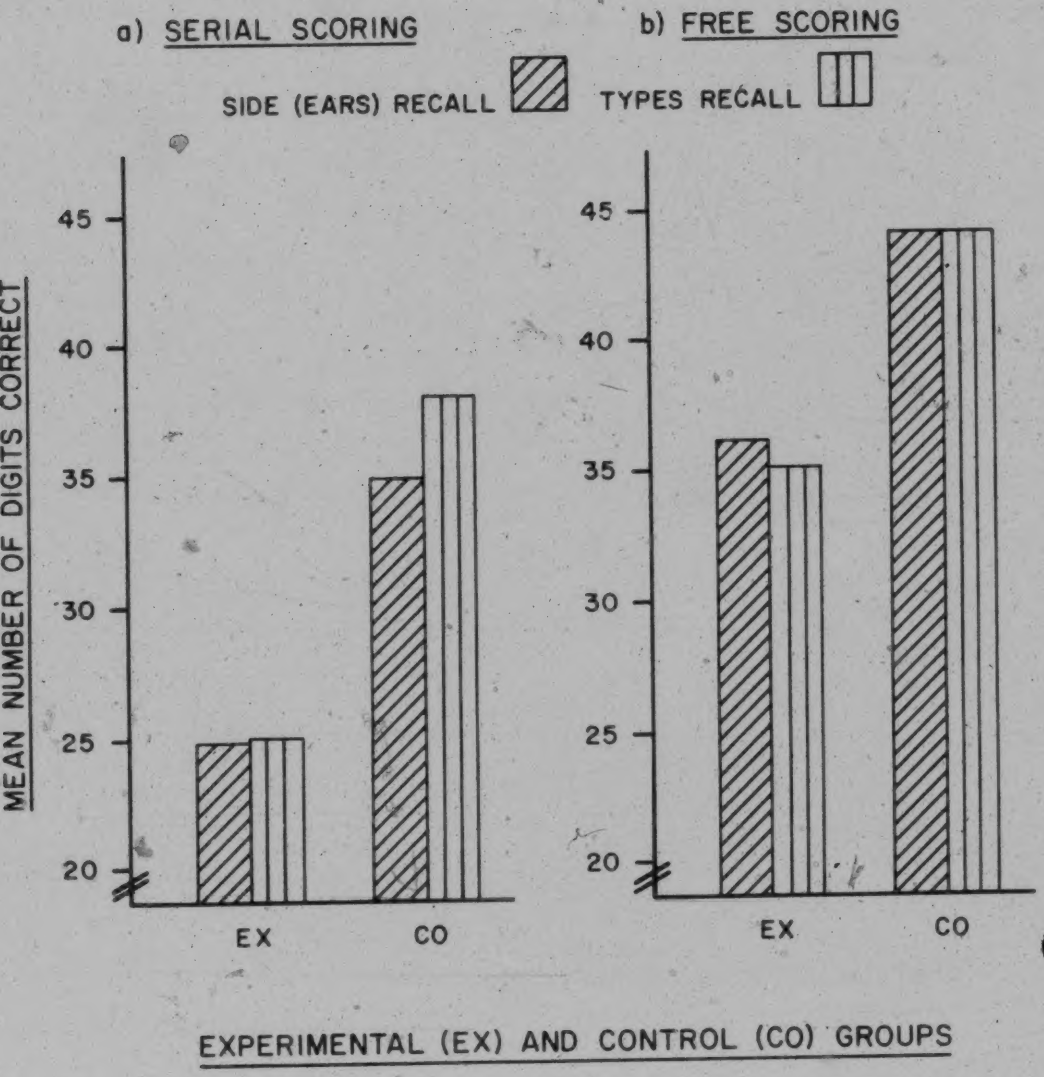

Figure 7-17. Differences in recall as a function of strategies (sides and types) for each group.

cultural-familial group, between the sides and types strategies using similarly composed stimuli (digits and letters). Using digits and words, Yntema and Trask, however, established a clear superiority of types over sides strategy, thus buttressing their claim for recall as a search process. In other words, the elements by types are more reliably tagged as words or digits than as stimuli heard on the left or right ears. As an aside, where Yntema and Trask imply that grouping by types must be a retrieval phenomenon Katzin, Corballis, and Lockhart (1972) claim types as a basis for selective attention can take place during input. One can of course explain away these apparently conflicting findings by saying that the stimuli (letters) used by Neufeldt are not as meaningful as those (words) used by Yntema and Trask. One can further attribute the difference to the samples used: retarded and non-retarded by the former and university students by the latter team. The more important question is to infer the relative contribution of perceptual and memorial processes as discussed with Hypothesis 2 in Dichotic Listening Experiment 1. The better recall under serial scoring of types than sides for the Control Group, but not for the Experimental Group, seems to augment the argument of memorial processes, as advanced by Inglis and Sykes (1967). But how is one to explain the almost identical scores for the Experimental Group and almost exactly the reverse with free scoring? The more plausible explanation is the inability of children with severe reading dysfunction to use tags to process dichotic stimuli or possibly the slight pull of perceptual forces vis-a-vis memorial ones for this group. This indirect evidence seems to confirm the earlier statement that given the nature of the present stimuli it is difficult to assess with great precision the relative contribution of cerebral asymmetry and memory. These processes are, among other things, a function of the group of children tested, their age and stimulus materials. It may, however, be safe to assert in a crude analogy with Hebb's (1949) intelligence A and Intelligence B, that there are two main determinants to recall of dichotic stimuli: a completely necessary perceptual mechanism and a completely necessary memorial process. With disabled readers the former mechanisms will set the limit while with their normal reading counterparts they are more likely to use more efficient processing strategies.

7.3.2 Hypothesis 5--Recall of Digits and Letters

A rider from the immediately foregoing hypothesis is the relative contribution of digits and letters within the types experiment (DL3). Do digits or letters carry more weight for their correct recall by types? The literature on short-term memory seems to suggest digits are easier to memorize and to recall than letters of the alphabet but the explanations are not clear-cut. The experimental results in mean scores are shown for both serial scoring and free scoring in Table 7-7.

Table 7-7

Means for Two Groups (A), Two Kinds of Stimuli (Dichotic Digits and Letters) with Types Serial Scoring and Free Scoring

Group	Types Serial Scoring		Types Free Scoring	
	Digits	Letters	Digits	Letters
Experimental (EX)	13.40	11.41	18.79	16.14
Control (CO)	18.05	20.16	21.67	22.50

These results are graphed in Figure 7-18. In the separate group x stimuli (digits/letters) repeated measures ANOVA the group main effect is highly significant (for serial scoring $F = 89.76$, 1/114 df, $p < 0.001$; for free scoring $F = 48.00$, 1/114 df, $p < 0.001$). With both scoring the stimuli main effect is not significant (for serial scoring $F = 0.002$, 1/114 df, $p = 0.9636$; for free scoring $F = 0.885$, 1/114 df, $p = 0.3489$). The interaction effect is also not significant (for serial scoring $F = 2.554$, 1/114 df, $p = 0.1128$; for free scoring $F = 3.212$, 1/114 df, $p = 0.0757$).

It should again be pointed out that Hypothesis 5 is a corollary to and derivable from the previous one. In the present rider, an attempt is made to assess the relative strength of recall of digits and letters juxtaposed in dichotic listening tasks. On the strength of short-term memory, one would expect digits to be better recalled because of their apparent "familiarity" and the small pool (10 digits from 0 to 9). Even if this were sustained for auditory stimuli, the suggestion did not hold in the present study as only 10 letters were used and the children were told of these stimuli before experimentation. The more acceptable suggestion is the finding from listening tests that some 10 dB less noise is needed for the intelligibility of letters to equal that of digits when both are masked with noise (Conrad, 1965). More important still is the question of confusability of beginning consonants and syllables in varying acoustic environments. The contributions to speech perception of the Haskins group and related researchers are relevant and deserve further attention in dichotic studies (Section 5.3).

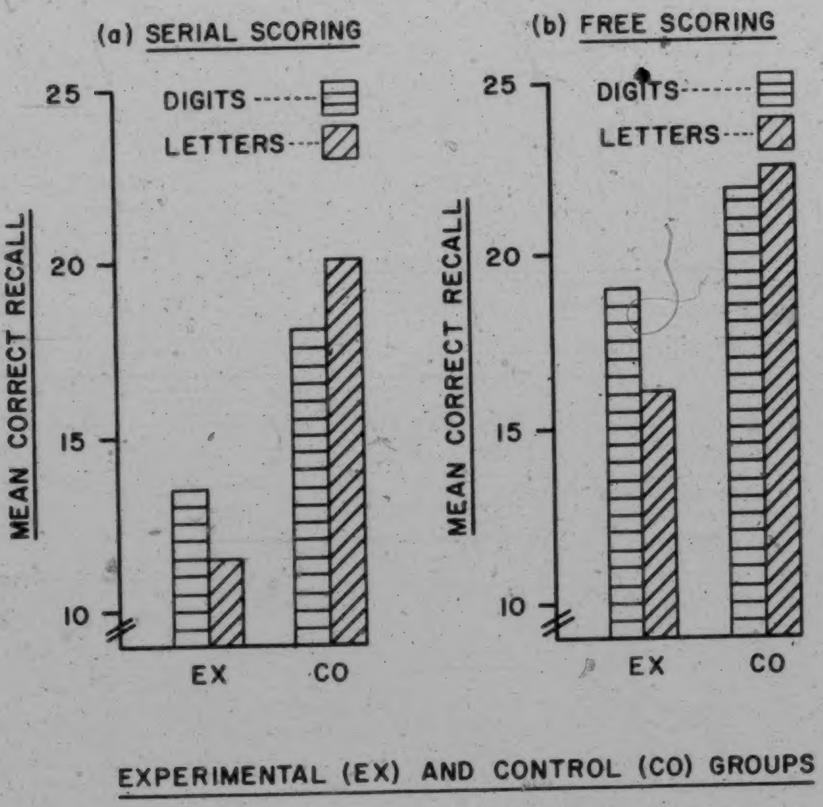

Figure 7-18. Mean number of digits and letters recalled by two groups for types serial scoring and free scoring.

7.4 Main Findings of Study I Summarized

This chapter begins with a detailed explanation of two methods of scoring (ear order and attempted ear order scoring) and proceeds to the testing of a series of interlocking hypotheses. The questions raised and answers advanced can be briefly restated. The overall right ear dichotic effect for both disabled and non-disabled readers considered as groups is demonstrated. However, when more analytic group comparisons are made, disabled readers perform significantly worse in the overall right ear superiority vis-a-vis their counterparts equated for age, sex and ability. This differential performance is taken as prima facie evidence of a lag in functional cerebral development of the Experimental Group. This explanation of slightly poorer right ear performance without implying that disabled readers have better left ear scores or that readers with better left ear performance are necessarily at risk is consonant with the cerebral maturational lag hypothesis (Bakker, 1973; Satz and Sparrow, 1970). While the difference may be influenced by memorial factors, evidence tends to suggest the greater potency of perceptual asymmetry. A more definitive answer needs to take into account more refined stimulus control such as onset synchrony of stimuli and the nature of speech elements in varying acoustic environments. The differential performance of the two groups is also related to the series lengths of the stimuli (digits) and suggestions are made as to the optimal length which may reduce interaction effects. An important finding is the ineffective and inefficient use of strategies by disabled readers when they are specifically instructed to report dichotic materials by sides (left/right half-span) and types of stimuli (digits/letters of the alphabet). As a corollary an attempt is made to assess the relative contribution of digits and letters in the types recall strategy. This search for constructs of information-processing is the substance of Study II to be discussed in the next chapter.

CHAPTER 8

RESULTS AND DISCUSSIONS OF STUDY II--TWO CORRELATIONAL STUDIES OF SIMULTANEOUS-SUCCESSIVE SYNTHESES

> Most of our skill in dealing with the environment is embodied in elaborate heuristics, or rules of thumb, that allow us to factor--approximately--the complex perceived world into highly simple components, and to find--approximately and reasonably reliably--the correspondences that allow us to act on that world predictably. This is the skill that the adult businessman uses when he makes a decision, the skill of a scientist in his laboratory, the skill of a child learning to speak.
>
> Herbert A. Simon, Allen Newell.
> Computer Simulation of Human Thinking and Problem Solving.
> In Kessen, W., and Kuhlman, C. (Eds.) Thought in the Young Child, Monog. Soc. Res. Child Development, 1962, Serial No. 83, 137-150.

8.1 Rationale of Methods

Insofar as Study I is more concerned with the successive processing of simultaneous information, Study II delves more into the products of related information and their synthesis. The three dichotic experiments examine strategies while the simultaneous-successive tasks analyse constructs. The rationale of Study II is presented in Section 4.4 and the postulates are outlined in Section 6.1.2. The logistics of operation as a subroutine nested within the main programme are flowcharted in Figure 1-1.

Briefly stated, Study II aims at determining the information-processing patterns of the Experimental and Control groups with "method-independent" analyses. The overall study is presented as two sub-studies. The first one involves the main tasks described and commented on in Section 6.4, namely: Raven's Coloured Progressive Matrices (RCPM), Figure Copying Test (FCT), Memory-for-Designs Test (MFD), Auditory-Visual Coding (AVC), Visual Short-Term Memory Task (VSTM), Auditory Serial Recall Task (ASR), ITPA Visual Sequential Memory Subtest (VM) and ITPA Auditory Sequential Memory Subtest (AM). The second sub-study evolves from the first and adds Dichotic Listening 2 (Sides) and Dichotic Listening 3 (Types) to the foregoing 8 tasks. For each of the two sub-studies the pattern followed is that of testing for the significance of the group centroid in respect of the 8 or 10 tasks considered simultaneously to determine if the Experimental and Control groups do in fact come from the same population. If they do, there is some justification, if needs be, in combining the two groups for further data analysis. Otherwise separate analyses for each of the two groups are called for. The factor analytic model is used here, or strictly speaking, the principal component analysis and alpha factor analysis are carried out for the sub-studies. Factor matching techniques are employed to ensure "method-independent" results within each group for each sub-study. Factor matching is also carried out across the two groups for each study to determine the invariance of the underlying constructs. All analyses are performed with the aid of computer programmes available from the University of Alberta Division of Educational Research Services.

As factor analysis is the mainstay for data reasoning in Study II, some comments on methodology are in order. The literature on factor-analytic studies in the generic sense of simultaneous-successive syntheses (Section 4.4), or for that matter a large volume of construct studies of exceptional children, usually employs the principal component method with the eigenvalue-greater-than-unity criterion followed by varimax rotation. Some time ago Harris (1964) pointed out that the principal component analysis is a descriptive procedure yielding uncorrelated derived variables within the variable space and that the procedure is not a factor analysis in the Spearman/Thurstone sense. Armstrong and Soelberg (1968) showed how component analysis of intercorrelations among random normal deviates with expected values of zero might lead to apparently "good" structure following rotation of those components with eigenvalues greater than unity. This the writer could testify in an ad hoc exercise using his own principal component programme (with call for subroutines) to analyse 14 variables 11 of which were meaningful psychological entities while 3 were random variates. Armstrong and Soelberg pointed out the need for estimating factor reliability and suggested three approaches: split of original sample into two (or more) random subsamples and separate factor analyses on these; a priori specification of a model to provide a framework for the relationships amongst variables and factors; and Monte Carlo simulation. Recently, Dziuban and Harris (1973) have demonstrated that when one or more of the variables being analysed behave like random variables with little relationship with other variables the principal component solution will put the first component through the centroid of the common space and since other components are placed orthogonal to the first, it is likely that one will be put through the random variable as this variable is placed orthogonally to the other variables. One way to overcome this methodological problem is to use as many alternative methods as practicable and as the models permit so that "method-independent" results could be obtained. The other approach might be to use a method which will analyse the common space and which will not include the "random" variables to any great extent. The alpha factor analysis (Kaiser and Caffrey, 1965) appears appropriate.

The above dictum of a priori specification of underlying constructs of simultaneous-successive syntheses and of different methods of factoring is followed in the present study. The first-named is discussed in Chapter 4 and Chapter 6; the second-named will be taken up presently. The suggestion of estimating factor reliability by splitting samples is not attempted as the subsample of 29 boys from each group of 58 in relation to the number of tasks is too small in size for meaningful results.

The efficacy of these correct principles, which often elude workers in the factorial paradigm, is demonstrated by the present writer in a recent study of the psycholinguistic abilities of moderately mentally retarded children (Leong, 1974a). In the present study, an alpha factor analysis will be performed for each of the sub-studies involving an 8 x 8 correlation matrix and a 10 x 10 correlation matrix respectively. The alpha factor analysis is a method which will maximise the fit of the common factors for the sample of variables to the hypothetical common factors for the universe of variables in the domain. In essence, analysis is achieved by inverting the correlation matrix R and, from the result, deriving the squares of the multiple-correlation coefficients (SMC) for predicting each variable from the (n - 1) other variables in the matrix to serve as initial estimates for communalities and iterating to reach convergence. The alpha factor analysis is used because:

(a) It is a psychometric approach which provides an estimate of the common factors in the universe of tests. The square of the multiple correlation coefficient for predicting the test from all the other tests in the universe of tests might be considered a "novel definition" of reliability of the test (Mulaik, 1972, p. 215).

(b) The alpha factor analysis provides a basis for the number of factors. In this method factors are extracted from the data as long as the factor has positive generalisability. Kaiser and Caffrey (1965) have shown a common factor is "tenuous" when it has non-positive generalisability which occurs with eigenvalues less than or equal to unity. The heuristic rule is thus to extract and rotate factors with eigenvalues greater than unity.

(c) The alpha factor analysis is independent of the size of variable sample. As the number of variables increases relative to a given sample of cases generalisability of factors to the universe may or may not increase. As more variables are added to the data matrix the eigenvalue of a common factor will increase only if that factor accounts for some of the variance of the new variables.

Preceding the alpha factor analysis the usual principal component analysis with unities in the main diagonal and varimax rotation on components with eigenvalues greater than one will be performed. This despite the comments on the method presented earlier in this section as the component analysis provides useful first-approximation information and enables the computation of component scores, if such are desired for subsidiary studies. To test the stability of the constructs the rotated component and alpha analyses are tested for congruence with the Schonemann (1966) method, which provides a "goodness of fit" of the factor structures. Given the factor matrices for two factor analytic studies A and B, this method applies, from a least square approach, an orthogonal transformation matrix T to A to transform it as close as possible to B. The rotated A matrix then becomes an estimate of the target matrix B. Differences between the rotated A and the target B matrices are computed as an error matrix. The testing of the congruence of factor loadings from one method of analysis to another in this way constitutes one meaning of factor invariance (Quereshi, 1967). Only when the findings from one method reinforce those from another can claims of underlying products be made with some degree of certainty. A Schonemann match will also be carried out group for group for each of the sub-studies. This will reinforce both the homogeneity of group centroid findings derivable from Hotelling T^2 and the homogeneity of covariance studies carried out early on in the sub-studies. Whether the Experimental Group and the Control Group come from the same homogeneous population cannot be estimated with great precision prior to these multivariate analyses. From the way the sample is drawn and on the assumption that since important variables of age, sex and ability are equated there is reason to believe that th[illegible]o groups do not differ greatly in some "non-reading" tasks as charact[illegible]sed in sub-studies 1 and 2. On the other hand, there is stronger reason [illegible] believe that despite the apparent equivalence of the two groups, they are in fact different in some subtle ways, not the least among which are perceptual-memorial processes inherent in dichotic listening tasks and the processing of simultaneous-successive information. Another way of stating this is that the "non-reading" tasks provide the underpinning of the reading process. Despite the apparent similarity, task for task, in contents and experimental conditions, the tasks as a whole occupy different dimensions in information space for individual groups and in fact for individual children. This simultaneous-successive matrix will be delineated in subsequent sections.

8.2 Results and Discussions of Correlational Study I--Homogeneity of Group Centroid and Dispersion

Relevant descriptive statistics for the Experimental Group and the Control Group are shown in Table 8-1. Details of the statistical characteristics including the range and variances on these 8 tasks as well as on the dichotic tasks, chronological age and ability level are shown in Appendix P.

Table 8-1 shows that there is a considerable divergence in the performance of the two groups on all the 8 tasks, with perhaps the exception of ITPA Visual Sequential Memory Subtest (VM). To verify this divergence, the group centroid taking all the 8 variables conjointly into account was tested by Hotelling T^2 (Tatsuoka, 1971). Table 8-2 summarizes the results and should be compared with Table 8-5 for Correlational Study II. It can be seen that the vectors of the 8 variables, with the exception of the ITPA Visual Sequential Memory Subtest, are all significantly different. When the 8 tasks are considered simultaneously in linear combination the Hotelling T^2 of 154.186 and the

Table 8-1

Means (M) and Standard Deviations (SD) of Variables in Study II-1 for Two Groups

Variables	Raven's Coloured Progressive Matrices (RCPM)		Figure Copying (FCT)		Memory-for-Designs[1] (MFD)		Auditory-Visual Coding (AVC)		Visual Short-Term Memory (VSTM)		Auditory Serial Recall (ASR)		ITPA Visual Memory (VM)		ITPA Auditory Memory (AM)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Experimental Group (EX) N = 58	22.603	5.041	12.207	2.503	8.569	6.481	6.259	2.072	60.845	15.462	57.120	12.222	20.552	3.228	27.172	7.195
Control Group (CO) N = 58	28.189	3.702	14.552	2.019	4.431	3.024	8.155	1.617	82.914	11.584	72.172	8.484	21.983	3.416	34.310	7.804

[1] error score

Table 8-2

Hotelling T^2 for 8 Variables
for Experimental Group and Control Group Compared

Variables	Hotelling T^2	F-Ratio[1]	p
Raven's Coloured Progressive Matrices (RCPM)	45.472	5.335	0.000014
Figure Copying (FCT)	30.302	3.555	0.001088
Memory-for-Designs (MFD)	19.083	2.239	0.029949
Auditory-Visual Coding (AVC)	29.675	3.482	0.001316
Visual Short-Term Memory (VSTM)	74.379	8.726	0.000001
Auditory Serial Recall (ASR)	58.340	6.845	0.000001
ITPA Visual Memory (VM)	5.284	0.620	0.759441
ITPA Auditory Memory (AM)	25.776	3.024	0.004216
Group Centroid	154.186	18.0898	0.000000

[1] For 8/107 df F-ratio at 0.95 level = 2.0267.

F-ratio of 18.0898 are again highly significant. Since equivalent groups were used in the inquiry, the same data for the two-group Hotelling T^2 were further treated for matched groups (Tatsuoka, 1971, p. 80). The F-ratio of 16.9063 for 8/50 df for the matched groups is also highly significant (${}_{8}F_{50}$ at 0.05 level = 2.14 and at 0.01 level = 2.90).

From the analysis there is evidence that the Experimental and Control groups do not come from the same population. The non-significant difference for ITPA Visual Memory between the two groups may be due to ceiling effects and seems to be at variance with a number of studies which find this subtest of the ITPA to be discriminating between good and poor readers. This point will be further taken up. It cannot be emphasized too strongly that when there is a number of comparisons to be made the multivariate Hotelling T^2, rather than the univariate t test, should be preferred as chance alone with a number of t tests may lead to Type I errors (i.e., rejection of the null hypothesis when it is in fact true). This was actually found when the same 8 variables for the two groups were subjected to separate one-way analyses of variance (ANOVA). The F-ratio for the same variable (VM) is 5.287 which for 1/114 df gives a probability level of 0.0233. To buttress the finding of lack of homogeneity of group centroids as tested by Hotelling T^2 the homogeneity of covariance was assessed by Bartlett's homogeneity of dispersion test (Cooley and Lohnes, 1962, p. 62). The obtained F-ratio of 2.05246 for 36/43729.4 df gives a P of 0.000202. Thus the results of testing for the homogeneity of group centroid and of group dispersion reinforce each other and demonstrate that the two groups are disparate in respect of the 8 tasks samples.

8.3 Results and Discussions of Correlational Study I--Component and Factor Analyses

On the basis of findings in Section 8.2, two separate principal component analyses and two alpha factor analyses were carried out for each group. For reasons of space, the correlation matrix of the 8 variables is embedded in that for the 10 variables in Study II-2 (Table 8-6) and will not be repeated here. Inspection of the Table shows the inter-correlations are from modest to low and that in general the coefficients are lower for the Control Group than for the Experimental Group. This provides a small clue to the interpretation of the dimensions and will be taken up in Chapter 10 (Section 10.4.1). The analyses were carried out separately for each of the two groups.

8.3.1 Correlational Study 1a--Experimental Group

Results of the principal component analysis and the alpha factor analysis are shown side by side in Table 8-3 for ease of comparison. Both the unrotated components/factors and the varimax orthogonally rotated components/factors are displayed.

For the principal component analysis 3 components with eigenvalues of 2.687, 1.460 and 0.991 emerged and accounted for 64.21 percent of the total variance. It may be pointed out that the extraction of components with eigenvalues greater-than-one is at most a useful rule of thumb and should not be applied rigidly, particularly as the third eigenvalue here did not depart significantly from unity. For one thing, the number of factors is inextricably interwoven with the factor model and is a vexed problem in factor analysis. For another, there are alternatives and

Table 8-3

Dimensions of 8 Tasks in Study II-1a for Experimental Group (N = 58) by Principal Component Analysis and Alpha Factor Analysis

Tasks	Principal Component Analysis							Alpha Factor Analysis						
	Unrotated Components				Varimax Rotated Components			Unrotated Factors[1]				Varimax Rotated Factors		
	I	II	III	h^2	I	II	III	I	II	III	h^2	I	II	III
Raven's Coloured Progressive Matrices (RCPM)	.644	-.400	-.330	.684	.802	.138	-.149	.574	-.327	-.258	.503	.697	.121	-.051
Figure Copying (FCT)	.573	-.496	.244	.633	.694	-.095	.378	.523	-.337	.155	.411	.561	-.041	.308
Memory-for-Designs (MFD)	-.656	.449	.163	.658	-.808	-.073	-.012	-.644	.361	.142	.566	-.742	-.095	-.079
Auditory-Visual Coding (AVC)	.692	.151	.013	.502	.424	.526	.212	.571	.101	.007	.336	.372	.377	.236
Visual Short-Term Memory (VSTM)	.387	.111	.856	.895	.052	.142	.934	.366	.114	.480	.378	.090	.134	.593
Auditory Serial Recall (ASR)	.594	.624	-.246	.802	.105	.888	-.047	.566	.668	-.332	.877	.113	.929	-.018
ITPA Visual Memory (VM)	.514	-.038	.015	.266	.408	.272	.158	.399	-.001	.005	.159	.303	.207	.157
ITPA Auditory Memory (AM)	.518	.653	-.042	.696	-.010	.824	.129	.440	.487	-.026	.432	.050	.625	.196
% Total Variance				64.21	26.71	23.41	14.08				45.76	20.05	18.54	7.18
% Common Variance					41.60	36.46	21.92					43.83	40.50	15.67
Eigenvalues	2.687	1.459	.991					5.195	1.842	0.978				

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[1] Eigenvalues 15th iteration with tolerance level = 0.005.

equally practicable heuristics such as Cattell's (1966) scree test. Moreover, psychological meaningfulness should also be considered. In the present correlational study analysis was also carried out in strict accordance with the Kaiser-Guttman rule. The two components accounting for 51.83 percent of the total variance did not afford as meaningful an interpretation as the three components extracted. Similar considerations also dictate the extraction of three factors with the alpha factor analysis.

Without loss of generality, it can be seen the patterns in the two different analyses are similar in terms of the distribution of components/factor loadings and the relative size of loadings. Very broadly, Raven's Coloured Progressive Matrices (RCPM), Figure Copying (FCT) and Memory-for-Designs (MFD) loaded on Component/Factor I as expected from previous studies of Das (1972a, 1972b, 1973a, 1973b). This may be labelled according to the Luria-Das terminology as the simultaneous component/factor, although one may inquire into the nature of this dimension. Again, very briefly, Auditory Serial Recall (ASR) and ITPA Auditory Sequential Memory (AM) loaded on Component/Factor II with Auditory Visual Coding (AVC) straddling the first two components/factors. This second dimension confirms the Das' successive component. The reinterpretation of simultaneous-successive syntheses will be taken up in Chapter 10 (Section 10.4). Two further points should be noted. One is the low communality (h^2 of 0.266 in the component and of 0.159 in the alpha analyses) of the ITPA Visual Sequential Memory Subtest. A tentative explanation of the ceiling effect and hence lack of discrimination has been put forward, despite claims otherwise by other workers, in the section dealing with homogeneity of group centroid. It is likely that with the two groups under study, this ability may have matured earlier, a fact well recognized by Thurstone (1948, 1955) and pioneers in testing as Binet and Wechsler (see Section 2.2). It may also be that Visual Sequential Memory taps some "unique" ability not adequately sampled within the three components/factors examined. In fact, this is the case with Visual Short-Term Memory (VSTM) with a loading of 0.934 and h^2 of 0.895 for the component analysis and loading of 0.593 and h^2 of 0.378 for the alpha analysis. There is probably some unique quality inherent in the content and the perception of the task itself. For want of a better name this third component/factor may be labelled as Perceptual Organization.

The emergence of Visual Short-Term Memory loading on the third dimension seems to be at variance with previous findings. Without going into details here, it may be pointed out that were neat statistical entity the aim of the analysis the rigid application of the eigenvalue-greater-than-one criterion would have yielded only the simultaneous and successive components. As found with the two component extraction Visual Short-Term Memory would be aligned with the successive dimension (loading of only 0.340 versus 0.216) and also Auditory-Visual Coding (loading of 0.572 versus 0.418) while ITPA Visual Memory would fall into the simultaneous component (loading of 0.410 versus 0.312). When the two-component extraction is considered together with subsequent analyses and seen in context, this "Procrustean" approach is not deemed maximally meaningful psychologically. The full significance will emerge in subsequent sections. This also highlights the perplexing problem of indeterminacy of the factor analytic model as a slight change of task or different cutoffs for factors may lead to different results.

Comparison of the component and alpha factor analyses draws attention to the different models on which the methods are based. As the alpha method only analyses the common parts of the variables, the total percentage variance accounted for is necessarily lower (45.76). So also the communality. The underlying models aside, the methods should yield similar results were the interpretation of the simultaneous-successive matrix including the perceptual organization to be meaningful. The consistency was tested by the Schonemann procedure (1966) outlined in Section 8.1. When the principal component analysis and alpha factor analysis were compared for the Experimental Group by this method, the largest value in the error matrix was 0.347409 while the average sum of squares for the error matrix was 0.010659. While there is no statistical test associated with the Schonemann procedure, or for that matter with other methods, heuristic evidence is provided by Skakun, Maguire, and Hakstian (1972). In a Monte Carlo study of 1,000 matches in 22 different population A matrices, these researchers found that an average trace value (E'E) greater than 0.0145 and 0.0232 would indicate a difference in the pair of factor structures at the 95th and 99th percentiles respectively. According to this guideline, the observed trace value of 0.010659 would therefore show similarity of patterns from the two methods of analyses. Factor matching results, however, must be interpreted with caution. As factor loadings get smaller, they account for smaller portions of a subtest variance and contain a greater proportion of error variance attributed to the original factor loadings or from the process of normalization. Also, the "goodness" of a solution is a configural judgment and is measured by result, not by procedure. Indeed, Skakun, Maguire, and Hakstian are cautious in stressing that their "modest technique" is a beginning, not an end-point; and that there are unresolved problems including different sample sizes and different variance factors in the two samples.

Correlational Study 1a with the Experimental Group thus far can be summarized as follows. To achieve "method independent" results, two methods of analyses: the principal component and alpha factor analyses were used. Three components/factors were extracted. The first two dimensions are explained as simultaneous and successive in keeping with previous findings, although interpretation may not necessarily be the same while the third might be labelled as "Perceptual Organization." Credence to the invariance of these dimensions was provided by the non-significant average trace value tested with the Schonemann procedure.

8.3.2 Correlational Study 1b--Control Group

As with the Experimental Group both component and alpha factor analyses were carried out with the Control Group, and the loadings for the separate analyses were tested for equivalence with the Schonemann procedure. Table 8-4 sets forth the unrotated and rotated components/factors for each method of analysis. The structures of different factor models also apply here. As with the Experimental Group three components/factors were extracted, all with eigenvalues greater than unity. Without loss of generality, the basic marker tasks of Raven's Coloured Progressive Matrices, Figure-Copying and Memory-for-Designs all occupy the simultaneous dimension as before while the marker tasks of Auditory Serial Recall and

Table 8-4

Dimensions of 8 Tasks in Study II-1b for Control Group (N = 58) by Principal Component Analysis and Alpha Factor Analysis

Tasks	Principal Component Analysis							Alpha Factor Analysis						
	Unrotated Components				Varimax Rotated Components			Unrotated Factors[1]				Varimax Rotated Factors		
	I	II	III	h^2	I	II	III	I	II	III	h^2	I	II	III
Raven's Coloured Progressive Matrices (RCPM)	.454	-.651	.284	.710	-.079	.817	.190	.450	-.597	.290	.643	-.078	.754	.262
Figure Copying (FCT)	.436	-.192	.697	.713	.210	.739	-.350	.332	-.129	.477	.354	.169	.552	-.146
Memory-for-Designs (MFD)	-.363	.704	.115	.640	.185	-.585	-.514	-.359	.551	.077	.438	.126	-.443	-.476
Auditory-Visual Coding (AVC)	.665	-.178	-.104	.485	.387	.420	.399	.556	-.077	-.049	.318	.345	.294	.335
Visual Short-Term Memory (VSTM)	.555	.310	-.373	.543	.620	-.098	.386	.467	.249	-.211	.324	.500	-.041	.269
Auditory Serial Recall (ASR)	.618	.534	.023	.667	.817	.009	-.016	.468	.429	.036	.404	.635	.019	.002
ITPA Visual Memory (VM)	.347	-.334	-.683	.699	.040	.032	.834	.331	-.234	-.474	.389	.057	-.009	.621
ITPA Auditory Memory (AM)	.649	.567	.166	.770	.863	.083	-.138	.595	.614	.215	.777	.862	.096	-.157
% Total Variance				65.34	25.38	21.89	18.08				45.59	19.61	14.58	11.40
% Common Variance					38.82	33.49	27.67					43.02	31.97	24.99
Eigenvalues	2.202	1.802	1.224					3.846	2.583	1.576				

---

[1] Eigenvalues 9th iteration with tolerance level = 0.005.

ITPA Auditory Sequential Memory all load in the expected successive dimension. But with this analysis Visual Short-Term Memory also loaded appreciably on the latter dimension with Auditory-Visual coding almost straddling the three dimensions and the ITPA Visual Sequential Memory occupying almost a "unique" position. The Schonemann factor matching procedure yielded the largest error value of 0.219328 and the average trace value of 0.009197 which for the Skakun-Maguire-Hakstian guideline of 0.0145 and 0.0232 at 95th and 99th percentiles respectively was not significant. Thus again stability of the patterns is demonstrated.

While the generality of the simultaneous-successive syntheses has been demonstrated in separate analyses, the specificity of the dimensions should be interpreted with caution. In other words, as the magnitude of the loadings differ and as there is some shifting of some variables from one factor to the other the psychological reality of the simultaneous-successive syntheses as found with the Experimental Group is at most similar to but not identical with the matrix found with the Control Group. This statistical nicety is better understood by noting that Visual Short-Term Memory occupies a "unique" space with the Experimental Group whereas it shifts to the successive space with the Control Group. Similarly with the latter group ITPA Visual Sequential Memory now takes on what may again by termed a visual perceptual dimension. One explanation for this shift is the use of different "sampling bonds" in the brain as suggested by Thomson (Maxwell, 1972a, 1972b). It could also refer to the use of differential strategies in problem-solving. These aspects will be discussed in Chapter 10.

As a synthesis to Correlational Study 1a with the Experimental Group and Correlational Study 1b with the Control Group the rotated loadings for each group were tested for congruence with the Schonemann procedure to further determine the variance of the patterns. The largest value in the error matrix was 0.964648 and the average sum of squares for the error matrix was 0.089533 which for the Skakun-Maguire-Hakistian heuristic value of 0.0145 (85th percentile) and 0.0232 (99th percentile) was highly significant. This is to be expected from the homogeneity of group centroid analysis via Hotelling T^2 and the Bartlett's equivalence of group dispersion (Section 8.2) and verifies these earlier results. Thus the two groups are not homogeneous. While the general pattern of simultaneous-successive syntheses obtains, both the statistical and psychological nature of the dimensions have to be interpreted with caution.

8.4 Results and Discussions of Correlational Study 2--Homogeneity of Group Centroid and Dispersion

Correlational Study 2 included all the 8 variables used in Correlational Study 1 as well as the serial recall scores for Dichotic Experiments 2 and 3 for sides and types (DL2 and DL3). Since dichotic tasks generally require the successive processing of simultaneous information dichotic sides and types scores were hypothesized to load on the successive dimension. Descriptive statistics for all the 10 variables can be found in Appendix P. As with Correlational Study 1 the group centroid taking all the 10 variables conjointly into account was tested by Hotelling T^2. Table 8-5 summarizes the results.

Table 8-5

Hotelling T^2 for 10 Variables
for Experimental Group and Control Group Compared

Variables	Hotelling T^2	F-Ratio[1]	p
Raven's Coloured Progressive Matrices (RCPM)	45.472	4.188	0.000068
Figure Copying (FCT)	30.302	2.791	0.004218
Memory-for-Designs (MFD)	19.083	1.758	0.077602
Auditory-Visual Coding (AVC)	29.675	2.733	0.004996
Visual Short-Term Memory (VSTM)	74.379	6.851	0.000001
Auditory Serial Recall (ASR)	58.340	5.373	0.000003
ITPA Visual Memory (VM)	5.284	0.487	0.895376
ITPA Auditory Memory (AM)	25.776	2.374	0.014127
Dichotic Listening 2 (DL2)	31.788	2.928	0.002820
Dichotic Listening 3 (DL3)	93.150	8.580	0.000001
Group Centroid	172.157	15.8566	0.000000

[1] For 10/105 df F-ratio at 0.95 level = 1.9220.

This Table should be read in conjunction with Table 8-2 for Correlational Study 1. Again the group centroid differed significantly when all 10 variables were analysed simultaneously in linear combination. In addition to ITPA Visual Sequential Memory Memory-for-Designs (MFD) was found not to differ between the groups (p = 0.0776). The homogeneity of covariance was again assessed by Bartlett's homogeneity of dispersion test. The obtained F-ratio of 1.78787 for 45/42694.2 df gives a probability of 0.000912. Thus the results of testing for the homogeneity of group centroid and the equivalence of dispersion all converge to show the two groups do not come from the same population in respect of the 10 tasks sampled.

8.5 Results and Discussions of Correlational Study 2--Component and Factor Analyses

Following the foregoing (Study II-1) two separate principal component analyses and two alpha factor analyses were carried out for each group. The inter-correlation matrices for the 10 variables for the two groups are shown in Table 8-6 with the matrix for the Experimental Group shown above the diagonal and the matrix for the Control Group shown below the diagonal. Again, the inter-correlations are at most moderate with the coefficients for the Control Group generally lower than for the Experimental Group from inspection. As mentioned, the significance of this will be discussed in the light of Thomson's (1951) sampling theory in Section 10.4.1.

Table 8-6

Correlation Matrices for 10 Variables:
Experimental Group Above the Diagonal; Control Group Below the Diagonal

	RCPM	FCT	MFD[1]	AVC	VSTM	ASR	VM	AM	DL2	DL3
Raven's Coloured Progressive Matrices (RCPM)	1.000	0.410	-0.510	0.299	0.050	0.242	0.205	0.084	0.099	0.305
Figure Copying (FCT)	0.334	1.000	-0.405	0.282	0.241	0.052	0.193	0.036	0.015	0.145
Memory for Designs (MFD)	-0.428	-0.206	1.000	-0.313	-0.108	-0.098	-0.308	-0.138	-0.128	-0.153
Auditory-Visual Coding (AVC)	0.355	0.159	-0.204	1.000	0.235	0.460	0.221	0.253	0.173	0.285
Visual Short-Term Memory (VSTM)	-0.102	0.053	-0.033	-.351	1.000	0.118	0.140	0.207	0.209	0.243
Auditory Serial Recall (ASR)	-0.038	0.120	0.064	0.195	0.253	1.000	0.174	0.578	0.347	0.497
ITPA Visual Memory (VM)	0.186	-0.124	-0.343	0.169	0.169	0.101	1.000	0.216	-0.009	0.188
ITPA Auditory Memory (AM)	0.037	0.203	0.125	0.186	0.353	0.655	-0.010	1.000	0.211	0.410
Dichotic Listening 2	0.009	0.201	-0.057	0.199	0.343	0.502	0.112	0.488	1.000	0.401
Dichotic Listening 3	0.119	0.075	0.053	0.342	0.441	0.565	0.248	0.473	0.567	1.000

[1] error score

8.5.1 Correlational Study 2a--Experimental Group

Results of the principal component analysis and the alpha factor analysis are shown in Table 8-7 for ease of comparison. Both the unrotated components/factors and the varimax orthogonally rotated components/factors are displayed. For the principal component analysis three components with eigenvalues of 3.145, 1.643 and 1.006 were extracted, accounting for 57.94 percent of the total variation. For the alpha factor analysis three factors with eigenvalues of 6.595, 2.5223 and 1.0192 (3rd iteration with tolerance level = 0.05) were extracted with total variation of 40.40 percent accounted for. In both analyses the eigenvalue-greater-than-unity criterion was followed as also extraction for components/factors beyond the third one did not yield meaningful psychological interpretation. Attention is again drawn to the different factor models involved and the generally lower total variation accounted for as well as communality for each variables with the alpha factor model. Again, without loss of generality the simultaneous dimension can be identified with the usual tasks generally found in the Das battery: Raven's Coloured Progressive Matrices, Figure Copying, Memory-for-Designs. In these two analyses, Auditory-Visual Coding, also loaded on this dimension although the loading was not clear-cut. The reason for this will be taken up later. The successive dimension can be found again with the usual tasks: Auditory Serial Recall, ITPA Auditory Sequential Memory and as hypothesized Dichotic Listening 3 (Types), but less so the Dichotic Listening 2 (Sides). As with the analysis in Section 8.2.1 Visual Short-Term Memory formed a similar Perceptual Organization Component/Factor. Clustering equivocally with this third factor is

Table 8-7

Dimensions of 10 Tasks in Study II-2a for Experimental Group (N = 58) by Principal Component Analysis and Alpha Factor Analysis

Tasks	Principal Component Analysis							Alpha Factor Analysis						
	Unrotated Components				Varimax Rotated Components			Unrotated Factors[1]				Varimax Rotated Factors		
	I	II	III	h^2	I	II	III	I	II	III	h^2	I	II	III
Raven's Coloured Progressive Matrices (RCPM)	.581	-.477	-.157	.590	.153	.753	-.002	.516	-.354	-.116	.405	.145	.619	.030
Figure Copying (FCT)	.463	-.592	.276	.641	-.144	.705	.350	.456	-.432	.212	.440	-.109	.600	.259
Memory-for-Designs (MFD)	-.550	.563	.081	.627	-.051	-.788	-.049	-.551	.455	.072	.515	-.080	-.711	-.054
Auditory-Visual Coding (AVC)	.657	-.060	-.035	.436	.431	.466	.183	.571	-.033	-.021	.328	.327	.411	.227
Visual Short-Term Memory (VSTM)	.410	.055	.736	.712	.081	.115	.832	.375	.080	.312	.244	.109	.161	.455
Auditory Serial Recall (ASR)	.691	.461	-.277	.767	.866	.124	.024	.648	.470	-.374	.781	.867	.134	.106
ITPA Visual Memory (VM)	.444	-.243	-.305	.349	.254	.508	-.162	.368	-.151	-.097	.168	.173	.369	.038
ITPA Auditory Memory (AM)	.588	.449	-.236	.604	.774	.062	.027	.510	.340	-.184	.409	.606	.115	.168
Dichotic Listening 2	.451	.404	.358	.494	.456	-.073	.531	.353	.330	.176	.265	.322	-.022	.401
Dichotic Listening 3	.683	.324	.049	.573	.667	.178	.311	.619	.316	.041	.485	.540	.183	.401
% Total Variance				57.94	23.06	22.30	12.57				40.40	17.03	16.46	6.91
% Common Variance					39.80	38.48	21.70					42.15	40.74	17.10
Eigenvalues	3.145	1.643	1.006					6.595	2.522	1.019				

[1] Eigenvalues 3rd iteration with tolerance level = 0.05.

Dichotic Listening 2 (Sides). The reason for DL2 to almost straddle the successive dimension and this Visual Short-Term Memory also does, partly validate the a priori assumption of serial processing of simultaneous information. If DL2 does not provide strong evidence at all, it may be due to the confounding of instructional strategies of specific reporting of stimuli from one ear or the other and the inherent perceptual-memorial processes. Whatever that was in Dichotic Listening 2, Dichotic Listening 3 came out strong and clear to buttress the successive dimension. As with the analyses reported in Section 8.3.1 and 8.3.2 the "goodness of fit" of the two methods were tested with the Schonemann procedure. The largest value in the error matrix was 0.379923 and the average trace value was 0.011846 which according to the Skakun-Maguire-Hakstian guideline of values of 0.0145 at 95th percentile and 0.0232 at the 99th percentile was not significant at the 0.05 level. Thus statistically, stable constructs are afforded and verified by two independent methods.

Correlational Study 2a with the Experimental Group can be said to further demonstrate the statistical and to some extent psychological reality of the simultaneous-successive matrix as found with both the component and alpha factor analyses. Once again the emergence of Visual Short-Term Memory as a "Perceptual Organization" dimension requires some explanation. This may be attributable to the nature of the task itself and processing strategies to be discussed in Chapter 10.

8.5.2 Correlational Study 2b--Control Group

As with the Experimental Group both the component and alpha factor analyses were carried out with the Control Group and the loadings from the separate analyses tested for equivalence with the Schonemann procedure. Table 8-8 shows the unrotated and rotated component/factors for each method of analysis.

For the principal component analysis three components with eigenvalues of 3.150, 1.869, 1.249 were extracted with total variation of 62.69 percent accounted for. For the alpha factor analysis three factors with eigenvalues of 5.627, 3.006 and 1.742 (to 2nd iteration with tolerance level = 0.05) emerged, accounting for 45.68 percent of the total variance. Once again, without loss of generality, the simultaneous dimension is identified with the marker tests of Raven's Progressive Matrices, Figure Copying and Memory-for-Designs together with Auditory-Visual Coding. The successive dimension emerges with Auditory Serial Recall and ITPA Auditory Sequential Memory as consistently found with Correlational Studies 1a, 1b and 2a. Furthermore, the two dichotic tasks (sides and types) cluster round the same dimension as safely assumed a priori. The Visual Short-Term Memory also loads on this component/factor. With both analyses the main task occupying the third dimension was the ITPA Visual Sequential Memory which may be "unique" or more likely may denote a similar kind of "perceptual organization" suggested previously. Schonemann factor matching gave the largest value in the error matrix as 0.246708 and the average sum of squares for the same error matrix of 0.007274 which was not significant at the 0.01 level with the same Skakun-Maguire-Hakstian guidelines. Once again, the homogeneity of methods in no way indicates

Table 8-8

Dimensions of 10 Tasks in Study II-2b for Control Group (N = 58)
by Principal Component Analysis and Alpha Factor Analysis

Tasks	Principal Component Analysis							Alpha Factor Analysis						
	Unrotated Components				Varimax Rotated Components			Unrotated Factors[1]				Varimax Rotated Factors		
	I	II	III	h^2	I	II	III	I	II	III	h^2	I	II	III
Raven's Coloured Progressive Matrices (RCPM)	.191	.774	.254	.700	-.025	.828	-.115	.264	-.672	.234	.575	-.041	.727	.213
Figure Copying (FCT)	.286	.350	.721	.724	.197	.533	-.634	.268	-.220	.459	.330	.170	.514	-.193
Memory-for-Designs (MFD)	-.100	-.781	.100	.629	.124	-.749	-.229	-.188	.632	.076	.441	.109	-.496	-.427
Auditory-Visual Coding (AVC)	.512	-.417	-.077	.441	.373	.520	.179	.484	-.247	-.041	.297	.326	.324	.293
Visual Short-Term Memory (VSTM)	.600	-.088	-.305	.460	.592	.026	.331	.527	.118	-.196	.330	.515	-.026	.254
Auditory Serial Recall (ASR)	.752	-.280	.085	.651	.802	-.048	-.072	.645	.328	.075	.529	.727	.008	-.037
ITPA Visual Memory (VM)	.267	.414	-.677	.701	.123	.348	.751	.267	-.282	-.448	.352	.094	.048	.584
ITPA Auditory Memory (AM)	.742	-.285	.245	.692	.799	-.028	-.231	.655	.350	.238	.608	.754	.086	-.180
Dichotic Listening 2	.745	-.131	.061	.576	.753	.088	-.025	.646	.186	.062	.456	.665	.108	.043
Dichotic Listening 3	.811	-.096	-.163	.693	.800	.100	.206	.766	.187	-.163	.649	.761	.019	.262
% Total Variance				62.69	31.50	18.69	12.49				45.68	25.41	11.66	8.61
% Common Variance					48.65	31.01	20.34					55.64	25.53	18.84
Eigenvalues	3.150	1.869	1.249					5.627	3.006	1.742				

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[1] Eigenvalues 2nd iteration with tolerance level = 0.05.

the component/factor patterns are identical, similar though they may be. Even with the statistically similar constructs the Schonemann findings, or for that matter, factor analytic techniques, demonstrate the end-products and less of processes. For this and other reasons extended discussion of processes in the light of the invariant product results will be offered.

While Correlational Study 2b offers "method-independent" insights into constructs there is no statistical equivalence of these constructs when compared with the loadings of Study 2a for the Experimental Group with the same tasks. Factor match of the two groups with the Schomemann procedure showed the largest value in the error matrix as 0.9767 and the average sum of squares for the same error matrix was 0.0776 which was significant beyond the 0.01 level. This again should be compared with the analysis of homogeneity of group centroid and group dispersion reported in 8.4 and is not unexpected from these earlier results.

8.6 Synthesis of Main Findings of Correlational Studies

The analysis of dimensions for Correlational Study 1 and Study 2 has been presented systematically. Throughout, the principles of assuming a priori postulates and of testing these with different methods have been followed (Section 8.1). Results show that Hypothesis 6 with its derivatives is supported. The simultaneous-successive dimensions are indeed found together with a subsidiary dimension occupied mainly by the Visual Short-Term Memory Task or the ITPA Visual Sequential Memory Task in each of Study 1 and Study 2. The invariance of the dimensions is upheld group for group as verified with the Schonemann procedure.

While the generality of the findings holds the specificity alerts one to the vagaries inherent in the basic indeterminacy of factor analysis. Over the years mathematical models of factor analysis have undergone considerable refinement and this is matched by sophisticated methods of analyses made possible with the advent of high-speed computers. While other techniques might have been employed, the principal component analysis and the alpha factor analysis are deemed relevant to the research formulations (Section 8.1). In delineating dimensions that account for the common, specific and error variances mixed amongst the vectors, the component analysis avoids the source of indeterminacy and provides for constructs that are mathematically neat within the structures raised. By inserting the squares of the multiple correlation coefficients (SMC) for predicting each variable from the (n-1) other variables in the principal diagonal the alpha factor analysis circumvents the communality problems with the related number-of-factor question. Two other methods of analyses were also tried. One was image analysis (Guttman, 1953; Kaiser, 1963), which analyses the correlation matrix $R_{m \times m}$ by inserting the SMC's in the principal diagonal and making adjustments to the off-diagonal correlations to maintain the Gramian properties of the matrix. The other was the principal axes method with SMC's in the diagonal via a computer programme written by the present writer. These analyses, however, did not yield as substantive psychological meanings and will not be discussed here. The principal axes method, for example, implies a non-Gramian matrix and the possibility of one or more imaginary factors together with slightly inflated factor loadings.

The re-iteration of the rationale of factor models and their implications is meant to highlight methodological problems which might have eluded some workers. Another aspect is the careful and discriminatory selection of tasks for factor-analytic studies (Guilford, 1952; Mulaik, 1972, p. 340). Some years ago Thurstone (1947, p. 179) makes this clear:

> If the test battery is a hodgepodge of complex tests, there may not exist in the configuration any clues as to what the underlying functions may be; but this possibility is dependent on the intuition of the experimenter in assembling a significant set of measurements rather than on factorial theory and method as such.

Moreover, tasks should have high or known reliability. Since the factor loadings in a variable decrease in proportion to the square root of the reliability of a variable, low reliability will result in the factor loadings in this variable becoming so low that they might be overlooked. And yet paradoxically sometimes it is the smaller factors that may tap conceptually new or unsuspected influence in a domain.

Thus to obtain a clearer insight into simultaneous-successive syntheses answers must be found beyond the skeletal domains provided by factor analysis. While the skeletons form a mainstay, they need to be fleshed out and clothed. This can be done with a careful examination of the nature of the tasks and the information-processing strategies used by the children. So also with an appraisal of the meaning of simultaneous-successive matrix and its relation to the serial processing of parallel materials generally characteristic of dichotic experiments (Chapter 5). So that "age does not wither, nor custom stale" the infinite varieties of analyses, psychological reasoning--neuropsychological and indirectly epistemological--will do much to humanise the various "factors."

CHAPTER 9

SOME ILLUSTRATIVE CASES

> Reeling and writhing, and the different branches of arithmetic--ambition, distraction, uglification, and derision. Mysteries, ancient and modern, with seaography. Drawling, stretching and fainting in coils. Laughing and grief.
>
> Lewis Carrol, Alice in Wonderland.

9.1 Individual Differences

Of the deficiencies in the basic subjects mentioned here, the one Lewis Carrol shrewdly dubbs "reeling" in nine-year-old boys is the subject of concern. In common with other related studies, the present investigation thus far gains perspectives and enables generalizations to be made with greater force from the study of groups. Also like such studies, the investigation can acquire more depth from detailed case studies, time and resources permitting. From the statistical comparisons of experimental and control groups individual differences (ID) must be further examined. An important point raised by Jensen (1966) in the context of individual differences and concept learning should also be noted here. The effect of an experimental variable on the performance of individuals can often be masked and be quite different from the average effect on a group of individuals. In statistical terms, when there are significant subjects by independent variable interactions, we should be cautious in drawing conclusions concerning the effects of a particular independent variable based on group mean differences unless these are large and statistically significant. In humanistic terms, the out-Bottom Bottom "reeling and writhing" so vividly portrayed by Lewis Carrol are more than malapropisms; they are at once "reel" for the child and at times writhing for the teacher.

Mention has been made of the variability of individual disabled readers (section 2.4) and the plea for "intensive study of individual cases" from a no less vigorous experimental psychologist than Vernon herself (1957, p. 6). In an attempt to understand the reasons for and nature of the reading difficulties, a few cases were selected for study. Space necessarily limits extensive discussions and only some salient findings can be presented as illustrations.

9.2 Two Cases in Brief

9.2.1 Illustrative Example No. 1 -- Dean C.

Dean aged 9 years 5 months (October, 1973) obtained a Lorge-Thorndike non-verbal IQ of 110. He looked small for his age and enjoyed working at novel tasks, although the teacher explained that the boy needed a lot of coaxing to be motivated in his school work. He showed an early history of delayed and immature speech, which was carried over into his reading so much so that Dean still confused "th", "s" and "z" sounds. When tested by the investigator with the Schonell Word Recognition RIA test Dean could only read 12 words correctly and obtained a reading age of 6 years 2 months (after more than 3 years in school). The words he could read correctly were: "school, tree, book, flower, playing, light, egg, clock, bun, sit, frog, something." For "little" he read as "like"; for "milk", "melk"; for "round", "reading"; for "train", "tain"; for "summer", "sum". It was a struggle to read the 12 words correctly and to try to "sound out" the others. Quite clearly, he had little idea of how to segment words into syllables and was unable to sequence the parts into a rhythmic whole as with "postage" which he read as "pos...age". On the Illinois Test of Psycholinguistic Abilities his overall Psycholinguistic Age was 7 years 4 months and his scaled score (SS) was 29 (mean SS 36 and 1 standard deviation 6). He was able to perceive visual shapes quickly and correctly as shown by his significantly high Visual Reception Age score of 10 years 10 months. His greatest weakness was in the association of ideas visually (Visual Association Age score of 6 years 0 months) and verbally (Verbal Expression Age score of 4 years 10 months). His unexpectedly low Auditory Reception score of 5 years 0 months might in part be due to the lower reliability of the subtest and to the susceptability to error with the yes-no answer to the number of items presented auditorily. He also found it idfficult to express himself verbally or through association of visual ideas. He was unable to spell a word like school ("socool") and even got his last name wrong. Thus here we have the picture of a boy of average intelligence, without gross emotional problems, visual or auditory defects but reading at the beginning grade I level.

From Dean's conversation that he had an older brother Randy and that Randy's (last) name was C (Dean's own surname) too", the writer found that Dean came from a family with adverse home conditions. His father had little formal education, and was frequently given to the bottle. After the death of his first wife (Dean's mother) he had remarried about four years back. It was Dean's step-mother who gave the much needed stability to the family and Dean seemed to be quite happy in her care.

It is difficult to speculate on the effect home conditions might have on the child and on his learning. If it is said that adverse home conditions affect learning, it can also be said that there are in similar circumstances other children who yet rise above the odds. Whatever the effect is, the deficits in learning are brought on cumulatively. Chapter 2.2 has endeavoured to show the multiplicity of factors acting and interacting in their effect on learning. As with the proverbial camel, it is not one straw, but an accumulation of straws, that breaks its back.

9.2.2 Illustrative Example No. 2 -- Robert K.

Robert aged 9 years 9 months (October, 1973) obtained a non-verbal Lorge-Thorndike IQ of 116 when tested in the course of the inquiry, his Binet L-M IQ being 115 as assessed some six months earlier. His reading performance fluctuated between the mid-grade 2 to beginning grade 3 level. He was selected for study partly because he was the "best" of the group of disabled readers. On the strength of quantitative reading scores obtained in one session only, he might not have been the most suitable candidate for placement in adaptation classes. Yet his variable and unpredictable day-to-day school performance together with the need to learn, re-learn and over-learn repeatedly the same word or the same sentence pattern made it necessary for him to have the kind of individualized teaching provided in these rooms. His behaviour and attitude belied the visual description of dyslexia. He was a quiet boy given to school work, whom the teacher described as "pleasurable," rather than "writhing", to teach. His performance in reading and the field of writing and spelling can best be seen from his own work photographed in Figure 9-1.

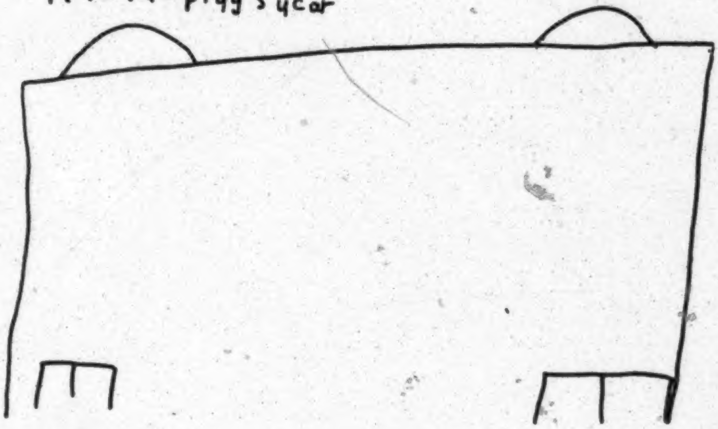
The sample drawing and writing, so characteristic of dyslexics (see Critchley, 1964, 1970), affords a great deal of insight into the nature and specificity of the difficulty with read and written language. The work was executed (and painfully) in two separate sessions, each one extending over some 35 minutes. The outcome of the labour for session I was the top half of Figure 9-1 (the drawing and the sentences at the top). The work originally occupying the full page 8½" by 4½" has been reduced to about half its actual size. The drawing was done at the end of a short task when Robert was asked to draw anything he liked on paper (work in pencil subsequently inked by the present writer). When he said he would draw his school, the investigator asked him to talk freely about it first: about the location, layout, shape, special features and other topics of interest related to the building. Only after some ten minutes of exchanges did the boy put pencil to paper. The results are interesting for a number of reasons. Despite talking about a topic, which has been found to contribute to the meaningfulness of drawings of even younger children, the sample shown is singularly devoid of details for a boy nearly 10 years old. The bare enclosure with two windows jutting out at the top and two doors below betrays impoverished ideas and cannot be attributed to the motoric aspect of drawing. This immaturity is also backed by the observation that the boy had little notion of the flow and utilization of space as nearly the whole page was taken up in the original. This difficulty in achieving visual-motor integration and its ramifications will be fully explored in the discussion of the figure copying and Memory-for-Designs tasks in particular in Chapter 10.

The is mei Sboch

it iS a big Scoolk.

it is fun plyy Sycar

I bot lik wa-ding bus



I to pyt Thebytn

Me mowfd To a wew nome'

it is far fue me Scock

I lock chin.

Figure 9-1. Sample drawing and writing from memory of the "best" disabled reader aged 9 years 9 months with a Binet IQ of 115. Top illustration (drawing and sentences) originally occupying the full page (8 1/2" x 4 1/2") has been reduced to about half the scale. The bottom illustration is the exact size.

While the drawing is interesting, the writing from memory at the top and below is even more instructive. The top four sentences, when deciphered, read "This is my school", "It is a big school", "It is fun playing soccer" and "I don't like waiting for the (a) bus". The bottom sentences should be: "I put my boot on", "We moved to a new home", "It is far from my school" and the last one would be left to the imagination of the reader! The writing (if not writhing) displays all the classical symptoms of strephosymbolia so presciently described by Orton (1925, 1937) some fifty years ago and by workers since (see Sections 2.3, 2.4). Among the main deficiencies these may be mentioned:

(a) The unsuccessful attempt at auditorization ("mei" for "my", "lik" for "like", "wading" for "waiting", "sycar" for "soccer", "fue" for "from", "byt" for "boot", "mowfd" for "moved").

(b) The inconsistent spellings related more to (a) above: "sboch", "scoolk", "scock" all for the same word "school", and "mei", "me" for "my".

(c) The fusion or telescoping of symbols in terms of words and phrases: ("plyy" for "playing", "I botlik wading bus" for "I don't like waiting for the bus", "mebytn" for "my boot on").

(d) The omission of words or syllables in connection with (c) above: "for a" omitted in fourth sentence above the drawing and "on" spelled as "n" in "bytn".

(e) The addition of words as in the first sentence beneath the drawing.

(f) Failure to use punctuations such as capitalization and periods.

(g) The ubiquitous "reversals" of "me" for "we", "mowfd" for "moved", "wew" for "new". This often cited polemic will be discussed in Chapter 10 (Section 10.2).

(h) Generally impoverished and uneven writing.

(i) Generally impoverished train of thought as shown in the jumping from the mention of "play sycar" to "wading bus" to "put mebytn" to the "wew home". This supports the developmental lag shown in the drawing.

9.3 "Reading Ineptitude" and N=1

From knowledge of Robert: his above average tested intelligence, his willingness to learn, one wonders if there are other factors (Section 2.2) impeding his reading progress. For that a glimpse is provided from the Dyslexia Schedule (McLeod, 1969) completed by Robert's parents.

Very briefly, the Schedule consists of 89 nucleus items probing anomalies in the early developmental and social history of the children and may be considered a standardized instrument of "reading ineptitude." It is singled out by the NINDS Monograph No. 9 (Chalfant and Scheffelin, 1969) as one of the very few properly validated scales found to be efficient and effective for the early screening of children "at risk" for dyslexia. From his clinical and factorial studies, the author states that 6 or more adverse responses (basically marked deviations in developmental milestones such as walking, talking and pre-, peri- and post-natal risks) *probably* constitute "a *necessary* condition for the diagnosis of dyslexia, but not a *sufficient* condition." (McLeod, 1969, p. 17, italics for last two words the author's). McLeod further adds that an Adverse Responses (AR) score of 6 or more reinforced by significant deficiencies in skills measured by such tests as the Illinois Test of Psycholinguistic Abilities should alert the parents or school to the likelihood of a case of reading disability. In the present instance, Robert obtained an Adverse Responses Score of 9 which thus provided some prima facie evidence of early "danger" signs. These included early hospitalization, irrational fear of the dark, sibling difficulties with reading and spelling and in particular, delayed speech development at 2 years 6 months. In the light of discussions in Section 2.2 it is clear these adverse conditions contribute to Robert's difficulties in a multifactorial way. At the same time these tell-tale signs should alert people concerned to the possibility of some aggravating problems at the grade 1 or even the Kindergarten level rather than having to wait until the boy reaches higher grades for his reading problem to surface.

As a matter of interest and to further explore this aspect of early detection, cooperation was sought from the parents of the 58 disabled readers to complete the Dyslexia Schedule. Of the 45 completed forms from the 45 families (78 percent) who consented, one had to be discarded because of stated lack of detailed knowledge of the child (adopted at age 2). Of the 44 completed schedules, 26 or 59 percent showed Adverse Responses Scores greater than 6. Inspection of the retrospective answers of these 26 AR>6 scales show the salient deviations were in this order: direct members of the family experienced difficulties in reading and writing (20/26); irrational fears of the dark or nightmares by the child (17/26); delayed speech (usually after age of 2) (13/26); immature talk (13/26); frequent short absences from school (7/26) and premature birth (3/26). The first-named Adverse Response of a preponderant number of direct family members (father, mother and siblings) also have reading difficulties and the fact of two pairs of dizygotic twins in the disabled group remind one of suggestion of hereditary disposition of Critchley (1964, 1970) and Hermann (1959). Whatever inference one can draw here is merely suggestive, but the evidence is there.

The bio-medical and cultural-familial correlates of specific reading disability are not the subject of main concern in this investigation and are only of tangential interest. The details will be presented elsewhere and will not be entered into here. Because of this indirect interest the Control Group was not included for this subsidiary analysis for a number of reasons. Thus the patterns found in the 44 completed forms should be regarded as descriptive of the early at-risk signs. It is significant to note that some 60 percent exceeded the threshold of "adverse responses". The large proportion of sibling difficulties seems to indicate the claim of hereditary disposition (Section 2.2); and the number with delayed and immature speech, the conviction of this writer and previous findings of reading difficulty considered as a language continuum (Section 3.1). It should be emphasized as Pasamanick and Knobloch (1966) and Walker (1966) did, that these anomalies of constitutional factors, delayed or missed developmental milestones and sequelae of birth hazards, must not be attributed to innate racial or social characteristics and that the variables operate multifactorially. In terms of occupations of the bread-winner (in most cases the father), they included 1 physician, 2 chartered accountants, 1 technologist, 3 managers with the next being mechanics, skilled laborers. Thus any extrapolation to link specific reading disability to social economic status is at best unwarranted and at worst dangerous. Like some inborn errors, when specific reading disabilities strike, they strike not singly at the lower socio-economic status but indiscriminately, albeit some individuals are more vulnerable than others.

While individual cases are of interest in and of themselves, they need to be viewed in the context of group differences as well. With no information about inter-subject variability in performance, the general applicability of findings is indeterminate. This should not be taken to mean that N=1 studies are inconsequential. Early literature on memory studies and extant clinical work in abnormal psychology are replete with such studies. Two strong proponents among others, Dukes (1965) and Shapiro (1961, 1966, 1970), have viewed the usefulness of an N of 1 in research as extending beyond the clinical field and that the two orientations--towards uniqueness and generality--are more a matter of degree than one of mutual exclusion. An elegant example is provided by Prick (1971) in a 7½ year follow-up of an autistic child Mariet from age 8 to 15½. The thorough clinical finding and the metaphysical theorizing of autism as an existential-developmental disorder amply demonstrate the rapprochement. McNemar (1940, p. 361) put this well some time ago:

> The statistician who fails to see that important generalizations from research on a single case can be acceptable is on a par with the experimentalist who fails to appreciate the fact that some problems can never be solved without resort to numbers.

9.4 Discussions of Studies of Individuals

In drawing attention to the poor prognosis of children with severe reading disability, one is sometimes countered with the doubt of "whither reading" in a world of multi-media. McLuhan's (1964) notion that the print medium tends to differentiate our perceptual world and that the electronic media tend to synthesize it is bandied about more as polemics than psychological facts. This does not mean that other media are not important. Far from it. Olson's (1970) postulate that the cognitive process consists in the performatory acts in various media that confront the individual with different alternatives has implications for a theory of instruction for both the non-disabled and disabled learners. Still, there is a definite place for the print medium as a source one can constantly refer to, rather than a total reliance on the electric medium with its successive and hence ephemeral messages.

That severely disabled readers tend to carry their reading problems with them unless remediated in good time and in great intensity is demonstrated in one of the few longitudinal studies of individual children as contrasted with group studies by Koppitz (1971). In a five-year follow-up of 177 learning disabled children aged 6 to 12 in a learning disabilities programme she found no less than 71 children remained in the same or similar programmes at the end of the four-year period. Lest this sounds pessimistic, a cheerful note is struck by Rawson's (1968) interesting follow-up account of 20 dyslexic boys who grew up to be successful professionals in later lives. It is also documented that in some perhaps rare instances "ex-dyslexics" grew up to become men of eminence in their respective fields, Edison and Hans

Christian Anderson being frequently cited as examples (Critchley, 1970, Thompson, 1966). Rawson is quick to point out that not all dyslexics are good professional risks and that her case studies simply show a glimpse of hope for psychologists, teachers and parents to tackle specific reading disability with renewed vigour. One message from the Koppitz and Rawson follow-ups is well put by Money (1966). He compares the neuropsychological disabilities that underline dyslexia to colour blindness. Like the latter, specific reading disability is not grossly incapacitating. Like the colour-blind person who is not necessarily disqualified even in fine arts, the dyslexic individual who can scarcely read road signs may be able to earn a living as a truck driver or in other skilled jobs which demand a minimal level of reading ability. Hope thus springs eternal to the human breast. Another message from Rawson and Koppitz is the need for early diagnosis and early treatment--a call now all too familiar. From the orthodox definition that a disabled reader does not constitute a problem until he learns to read, the current practice of leaving diagnosis to about the second or third year of schooling is much too late for effective treatment. The present investigation amply demonstrates that as a group children with specific reading disability not only have severe reading problems, but also perform poorly on a number of non-reading tasks as well. This affords further evidence that these children are a sub-group extending beyond the continuum of reading proficiency to deficiency (Section 2.4). With some refinements and modifications the present battery of spatial-temporal tasks can be used as a group or in conjunction with such battery as that of de Hirsch, Jansky,and Langford (1966) for the early diagnosis of at-risk cases initially screened from the Dyslexia Schedule. This practical application of the tasks further enhances their value as research tools.

From both the group and individual studies, one is alerted to the inadequacy of the operational definitions of children with specific reading disability discussed in Section 2.3. As explained, the 58 disabled readers all had average or above average intelligence and were free from emotional and sensory defects. Their severe reading problems are therefore puzzling. General ability is a necessary condition, but not a sufficient condition, for successful reading. Above a certain threshold, intelligence does not provide a valid clue for the reading task. There are subtle factors within the child and in the environment acting to impede his progress in reading (Section 2.2). The more potent ones are perceptual development and information-processing strategies and products postulated and tested in the investigation.

To recapitulate, this chapter discusses the need to examine individual differences and the usefulness of N=1 studies. Two actual cases from the reading disabled group are outlined to illustrate the variability and severity of specific reading disability. The Dyslexia Schedule is shown to be effective in screening "at-risk" children. Follow-up studies of severely disabled readers to adult lives paint a less pessimistic picture and further underscore the urgency of early diagnosis, timely treatment and above all prevention at younger ages.

PART III

INTEGRATION

CHAPTER 10

GENERAL DISCUSSIONS OF THE INVESTIGATION

> Even when an experiment apparently fully proves his preconceived ideas the experimenter must still doubt.
>
> Claude Bernard: An Introduction to the Study of Experimental Medicine. (1865), reprinted in 1957 (p. 52).

The above quotation reminds one of a similar dictum of Descartes. A parody of Coleridge on poetic faith is not inappropriate: "The willing suspension of belief constitutes scientific faith." It is in this spirit of inquiry that a synthesis of the theoretical considerations and empirical findings is attempted.

Reverting to the main "programme" together with the "subroutines" flowcharted in Figure 1-1, the present investigation rested on two major premises. From the postulates of functional lag in cerebral development and the differential information-processing strategies, experiments were designed to inquire into the nature of the asymmetrical development and tasks were assembled to delineate the simultaneous-successive matrix. The five chapters in Part II discuss singly and in concert the dichotic listening paradigm and related technical problems; the chapters also detail formulations and procedures and present the findings of each of the three experiments and of the two correlational studies together with two case illustrations. What follow are the discussions of the investigation as a whole. These will be presented under the broad headings: observations specific to the studies, to the children and to the tasks; and comments generalizing from the specificities as well as integrating the investigation as a whole.

10.1 Comments on Research Designs, Sampling and Tasks

In any study, skepticism of one's own work is healthy. The present investigation is no exception. Aspects of research designs, sampling and tasks could be refined and improved on for more efficient results. In the light of theoretical underpinnings and applied results brief comments will be offered here.

With his authority behind him, Broadbent's (1971, p. 5) dictum on the need to treat alternatives in the usual hypothetico-deductive psychological research is appropriate. He explains:

> . . . to treat each experiment not as a means of testing the presence or absence of a particular result, but as a way of dividing the set of all possible theories into as many classes as there are possible experimental results and then seeing which classes of theories are eliminated by the actual result obtained.

This is reminiscent of what Sir Karl Popper once said that a scientific experiment can at best only disprove a hypothesis, never prove it. We should then set up alternative hypotheses, disprove these to show that the data observed are consistent with the hypothesis which is thus not so much "proved" as is shown to be the most probable. The Broadbent dictum is largely followed in the attempt to provide alternative explanations for what is assumed to be. As mentioned, generalized findings can be supplemented with studies of "uniqueness" with individual cases and with observations of error. Not only this, true experiments should be attempted. While the nature of the present investigation constrained the use of the two-group approach, statistical inferences can be made with even greater force with randomized designs when children are randomly assigned to different treatments. This of course is dependent on the objectives and the nature of the inquiry. With the equivalent-group approach the difficulty of statistical regression has to be overcome (see Section 6.2). Moreover, it would be necessary to discover every antecedent variable that would significantly increase the within-group multiple correlation of antecedent variables with the dependent variable and to assess the antecedent variables infallibly or make adjustments for errors of measurement (Lord, 1960). Such a task is well-nigh impossible. The present investigation amply demonstrates that even with near equivalence for the variables of age, sex and ability, which are all germane to the problems under study, the two groups still differ significantly in a number of non-reading tasks. This means on the one hand that there are subtle differences, qualitative more than quantitative, which differentiate the disabled and non-disabled readers. The divergence also highlights the difficulties in ensuring "true equivalence." This was the problem confronting such workers as Doehring (1968); Naidoo (1972); Owen, Adams, Forrest, Stolz, and Fisher (1971) as discussed in Section 2.6.1, and one partially solved in the present investigation. A better way to bypass the impasse is to study the different conditions under which group differences occur. This was the intent of the dichotic experiments and could be exploited further.

Experimental designs aside, contents in both the experimental and correlational studies could be improved on. The accumulated literature on the dichotic paradigm shows that interest of researchers of neuropsychological persuasion continues unabated. The literature also points to trends for further research. It appears that there is a saturation of molar studies on the relations between handedness, perceptual asymmetry and reading disability. It also seems that cross-fertilized ideas from speech perception dictate more experiments with closer attention to the molecular nature of speech stimuli and their perception. This the present investigation attempted to do in a small way--with refined instrumentation and testing for synchrony of dichotic digits. Section 5.3 has already alluded to some current work on the dichotic paradigm deserving careful scrutiny. The salient points will be re-stated. Future research directed to these areas will yield more meaningful results:

(a) The effect of shadowing or transforming the stimuli such as subtracting a constant and cumulatively adding a number to the digits (Yates, 1972).

(b) Dichotic listening in relation to syntax (Bever, 1971; Zurif and Sait, 1970).

(c) The study of single dichotic pairs of syllables differing in some controlled way such as CV difference in place of articulation or in voicing (Shankweiler, 1971; Studdert-Kennedy and Shankweiler, 1970; Studdert-Kennedy, Shankweiler, and Pisoni, 1972).

(d) The lag effect where one dichotic word leads the other (Berlin, Lowe-Bell, Cullen, Jr., Thompson, and Loovis, 1973; Lowe, Cullen, Jr., Berlin, Thompson, and Willett, 1970).

(e) Developmental study of dichotic listening combining the refinements above (see Bryden and Allard, 1973; Krashen, 1973 for the psycho-acoustic orientation and Maccoby, 1967; Maccoby and Konrad, 1966, 1967 for the child developmental approach).

It can be seen the above refinements presuppose equally refined or sophisticated instrumentation for the preparation of dichotic materials and subsequent "quality control." While the specially devised instruments for the present experiments are both fairly precise and practicable, the ultimate is to utilize computer technology to adjust onset and perhaps offset synchrony, to control intensity and to achieve other desired acoustic effects. This is the current practice with large laboratories (e.g., the Haskins Laboratories). This does not mean that the individual researcher without these facilities should not pursue dichotic studies. It does mean that a premium is imposed on time, energy expended and precision of stimulus materials. What it also means is that results should be interpreted within the margin of errors expected. To save on time a variation of testing procedure may be tried. This is the multiple testing a small group of 3 to 5 children with earphones wired in parallel when the children would write down their responses rather than report them verbally. It should be pointed out whether some or all of the above refinements should be incorporated will depend on the objectives and nature of the experiments to be conducted.

One further technique relates to the vexed question of simultaneity-successivity so well expressed by Bergson (1922, cited by Fraisse (1964) as the quotation prefacing Chapter 7). That is the nature of reproductive serial order that dichotic listening tasks probe (Section 4.2) and should be further explored. Moray and Jordan (1966) have pointed out that Broadbent's verbal report technique involves dual input but only single output since we have two ears but only one tongue. It may well be the usual method of verbal reporting of all stimuli necessarily constrains these in a similar fashion. The use of a probe technique where the subject can respond simultaneously by, say, pressing on a panel of buttons with both left and right hands the digits/letters corresponding to the exact ear positions of both channels might produce interesting results (Yates, 1972). This would at least facilitate equal retrieval and provide for the possibilities of simultaneous responses to stimuli input simultaneously. Whether these stimuli must be treated successively as always claimed will be re-examined in subsequent sections.

These same constructive self-criticisms directed to dichotic experiments also apply to the simultaneous-successive tests. The imperfection of some of these tasks has been remarked on in Section 6.4. Further points will be added. Take, as an example, the Figure Copying test. On the related literature on this task there is a paucity of information on the quantitative scoring of the task, though not the qualitative aspect. The latter is in fact the more illuminating (Section 6.4(b)). To maintain consistency in awarding scores of 0, 1 to 2 according to the "correctness" of each drawing, the present writer devised a set of general principles in reference of the task as a whole and specific principles for each of the ten drawings. The details are shown in Appendix I. Inspection of the children's drawings showed that the task was on the whole too easy for both groups. The main between-group discrimination was provided mainly by 3 items: the cylinder and the two cuboids. Figure 10-1 shows the actual reproductions of some specimen drawings from six children and deserves attention. Without loss of generality, it can be said that the problem these children faced was

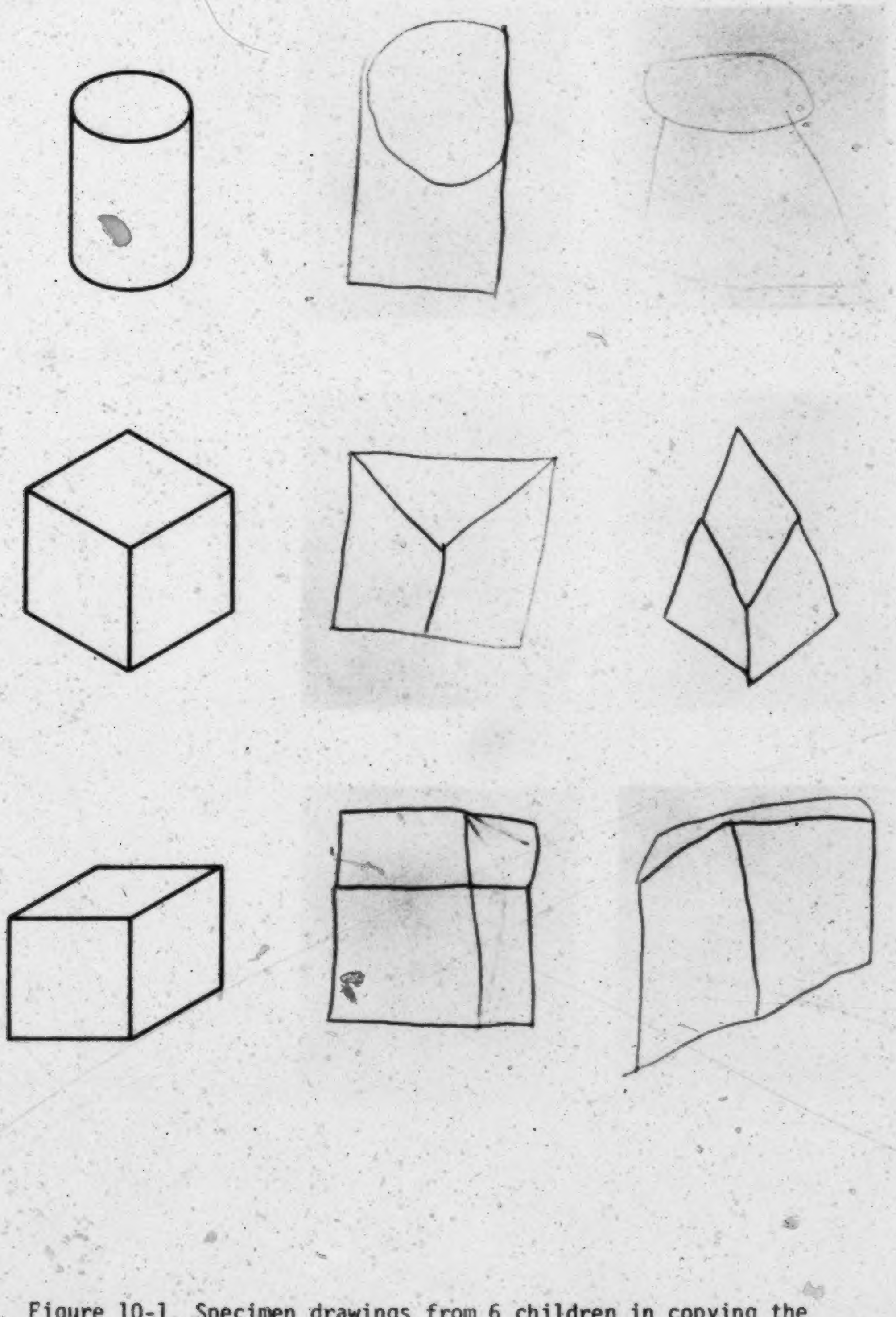
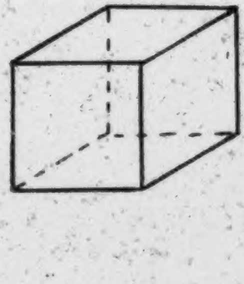
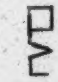
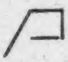
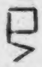
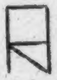
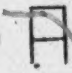
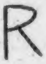
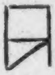


Figure 10-1. Specimen drawings from 6 children in copying the figures (shown on the extreme left) from the Figure Copying Task.

not one of visual perception, not was it one of the motor act of copying alone. It is one of visual-motor integration culminating in adequate visual analysis and the utilization of drawing rules. This aspect of search for rules will not be laboured here and will be subsumed under the general heading of information-processing strategies to be taken up presently in this chapter. Suffices it to say that strong proponents of similar tasks as Benton (1955), Harris (1963) and Koppitz (1970) have all emphasized the integrative aspect in copying or visual-motor retention tests. One further morsel of food for thought pertains to the cuboids. Perusal of the sample drawings and works from other children show that reproductions are almost perceived as two-dimensional rather than three-dimensional as intended. Is this due to selective attention or selective inattention such as the familiar fluctuation of attention with the well-known Rubin's Figure? With the instruction of copying the figures as they are perceived and in the absence of labels being given, would it not be in keeping with the developmental tasks of 9- or 10-year-old children to produce the kind of drawings as shown in the bottom right-hand photograph in Figure 10-1? That older children are able to reproduce "good" three-dimensional drawings are probably due to their knowledge of the label "cuboid" and its properties. To what extent would naming (e.g., cuboid, box, block) and discussion of essential features aid younger ones? What would the drawing results be like if the cuboids are shown with dotted lines as on the right? In short, what is the nature of "visual thinking" in the present context of information-processing?



That the Figure Copying test is singled out for detailed comments is because of the wealth of information the task generates. This qualitative aspect is too often masked by numbers. Another task that needs closer attention in scoring is the Memory-for-Designs test. The authors emphasize that orientation errors are heavily penalized while incomplete or forgotten designs are given little or no penalty. (Graham and Kendall, 1960). A careful examination of scoring examples given in the manual compared with the actual designs memorized and reproduced by the children show the need for clearer delineation of standards of scoring. For example, in Design 5  (appendix J) a drawing of  is given top score of 0 while  which is closer to the stimulus item in both orientation and completeness is penalized (error score of 1). Likewise in Design 14 , it is problematic if the specimen  or  (both given the highest score of 0 according to the manual) is superior to the neat sample of  (scored for error as 3) in both orientation and wholeness. There is a need to enunciate clearly the general principles and the specifics in scoring this test along the line of the writer's attempt with the Figure-Copying task. Similar observations can be made of the other tasks used in order to achieve more consistent results. In short, the point strongly stressed by Guilford (1952), Mulaik (1972), Thurstone (1947, p. 179) of careful selection of tasks for factor analysis is well put by the experimental psychologist Kolers (1970, p. 113) in a scholarly discussion of visual operations, grammar and meaning in relation to reading: "one way in which science develops is by understanding the role of the stimulus it manipulates."

10.2 Relevance and Importance of Reading Research Re-Affirmed

Huey (1908) quoted early in Chapter 2 is the embodiment of significant reading related research by cognitive and experimental psychologists initiated well before the turn of the century. Reading research by both psychologists and practitioners is now a field in its own right. The skepticism voiced by some practitioners about the efficiency of reading research is ill-founded (Section 2.6.1). Granted there is a gap between research emanating both from laboratories and from schools and the application of research findings, the gap is often made wider by cognate disciplines working in isolation, rather than in concert. Two specific "bandwagons"--one of old and the other of current vintage--will be cited to show the confounding of the horse and the cart.

10.2.1 Old "Bandwagon" of Whole Word Approach

The old "bandwagon" is the now largely discredited "whole word" approach to reading instruction, which was often attributed erroneously to the "meaningful whole" concept of Gestalt psychologists. The pros and cons of learning "by whole" in beginning reading are too well known to merit further discussion. Suffices it to quote Roger Brown (1958, p. 71-72) in a clear exposition of a systematic application of Gestaltean principles to reading:

> . . . When Gestalt theory calls our attention to 'wholes' it is to the system that determines the character of its parts. Are words the relevant 'wholes' for someone learning to read? . . . The relevant whole . . . is not the total series containing the individual (parts) but is, rather, the principle governing the series. Systematic learning gives insight in that it provides principles (not always verbally formulated) from which specific materials can be derived. In learning to read there seems to be more insight provided by phonetic rules than by the look-and-say method.

The above view coming some fifteen years ago from a psycholinguist is of interest. For one thing Brown does not condemn out of hand the "whole" word approach. There may be a few children who can benefit by the look-and-say method even though the English language is not so constructed as to be taught maximally with this (see also discussion of visiles-audiles in Section 2.4). For another, the meaning of "relevant wholes" has been the subject of studies and research over the decades and it is not until recently there is some consensus as to what the invariant units should be (Section 2.6.2). Further, the learning of implicit rules both at the morphophonemic and syntactic levels is advocated by cognitive psychologists and psycholinguists.

10.2.2 Current "Bandwagon" of Reversal Errors

The other bandwagon ridden hard is the current vintage known as visual perception training which, unfortunately, is still billed as the express from the literal and metaphoric Alpha to Omega! Despite strong evidence to the contrary by professionals of such stature as the empirica educationist Gates (1922), the experimental psychologist Vernon (1957, 1971), the neuropsychologist Benton (1962), the ophthalmologist Goldberg (1959) and the neurologist Critchley (1964, 1971) so-called visual perceptual deficiencies are still held up as a causal factor of specific reading disability. The practice of prescribing visual perception training programmes as the panacea to remediation is still not uncommon. This has led Mann (1970; Mann and Phillips, 1967) to decry the "fractionating" of educational practices when there is little evidence linking perceptual training and improvement in reading skills.

As a case in point, the usual attribution of reversal errors in disabled readers ("b" read as "d", "p" as "q" and the like) to visual functions in general shows at best a disregard for hard facts of research and the nature of the language. In the first place, there is no systematic knowledge of the frequency and consistency of reversals in beginning reading. Secondly, little is known of the proportion of reversal errors to other errors. In other words, are reversals part of the learning to read process and in what way do they constitute a problem? Nearly 40 years ago Orton (1937) differentiated between Kinetic or sequential reversal of letter sequences (e.g., "was" read as "saw") and static or orientational reversal of letter forms (e.g., "b" with "d", "p" with "q"). Without doubting the veracity of these errors and their relation to reading performance, he suggested that the Kinetic and static errors "vary markedly both in their relative frequence and in the resistence which they offer to eradication by retraining." (Orton, 1937, p. 150). Orton further made it clear that this impairment applies primarily to symbolic stimuli rather than to all visual stimuli--a distinction also endorsed by subsequent researchers (Benton, 1962, Money, 1962). Despite these pronouncements, studies of reversal errors are characterized more by polemics than facts.

One such rare fact borne of carefully controlled experiments is provided by Liberman and associates (Liberman, Shankweiler, Orlando, Harris, and Berti, 1971; Shankweiler and Liberman, 1972). Using real-word monosyllables, CVC nonsense monosyllables and tachistoscopic presentations of simple letters consisting of "reversible" letter forms and control letters, these workers study the errors of grade 2 children in terms of: reversal of sequence, reversal of orientation, of consonants, of vowels and of total errors. They note that the proportion of reversal errors compared with consonant and vowel errors is small and that there is great variability amongst poor readers. Their results can be summarized as follows:

(a) There is little relationship between errors due to reversal of sequence and reversal of orientation (Orton's Kinetic and static reversals respectively).

(b) Reversals are not just a problem in general form perception (see also Kolers, 1968, 1969, 1970); they are context-dependent rather than just a property of optical reversibility.

(c) That there are more "b" comparisons than "d" or "p" suggests a linguistic process more than a visual one as "b" offers the readers two opportunities to err by a simple articulatory feature (place or voicing).

(d) Error patterns in reading and speech are different although this does not mean the processes are not related (Section 2.6.2). The view that reversals are a symptom and not a cause of reading disability is salutary. The suggestion of "linguistic awareness" (Cooper, 1972; I. Liberman, 1971; Mattingly, 1972) is reasonable and explains why initial segments in words are more often read correctly and why vowel errors are more frequent in reading than in speech. This source of vowel errors is due not to their orthographic complexities but more to their complex mapping onto sounds and the consequent confusion for the reader to read phonetically. The Liberman and Shankweiler studies are discussed at some length because of their elegance, their generalizability to basic work and their specificities for both diagnosis and remediation of disabled readers.

10.2.3 Linguistic Awareness

The important question of linguistic awareness in early reading discussed in Section 2.6.2 needs greater elaboration. Linguistic awareness is interpreted to mean phonemic segmentation into syllables. This is epitomized in Figure 2-3 (see also Figures 2-4 and 2-5) in Chapter 2. The illustration of the acoustic signal for "b-a-g" shows that the initial and final consonants all fold into the medial vowel and that information is transmitted almost simultaneously. In a sense, the syllable "bag" with three phonemic segments has but one acoustic segment. Work in the area of speech perception and reading has demonstrated that speech sound is a complex code and not just a simple one-to-one cipher (Liberman, Cooper, Shankweiler, and Studdert-Kennedy, 1967; Kavanagh and Mattingly, 1972).

There are at least three additional sources of evidence in support of the importance of segmentation in learning to read: basic and applied psychological research on the reading process by the Russian psychologist El Konin (1963, 1973); clinical studies by Isabelle Liberman and associates (Liberman, 1971, 1973; Liberman, Shankweiler, Carter, and Fischer, 1972) and experimental work by Calfee, Lindamood and Lindamood (1973). In his ongoing work with beginning reading in Russian, El Konin emphasizes the syllable reconstruction of the sound form of words and the temporal order of the series of sounds in a word and spells out ways of representing concretely syllabication of speech materials. He is careful to point out that the child's aim is "not the symbolizing of separate sounds, but their separation and modeling as a succession." (El Konin, 1973, p. 563). The El Konin model of experiment is replicated with success with children learning English by I. Liberman (1971, 1973) and with Kindergarten through grade twelve children by Calfee, Lindamood and Lindamood (1973). Using multiple regression and analysis of variance techniques, Calfee and associates verify experimentally that there is a substantial correlation between auditory-phonemic skills and reading ability and that "poor readers have failed to master these [simple phonological skills] at the syllable level in all grades" (p. 298, writer's italics).

The little noticed Russian work and the experimental verification of the model by the Liberman and Calfee team are of both theoretical and practical interest. That implicit knowledge of syllable segmentation as a necessary condition for beginning reading provides a clue to the understanding of the reading process and its breakdown. It is, however, not a sufficient condition. Nor does it mean that all beginning readers should be taught by this approach. What it does mean is the re-examination of "perceptual training" and the re-affirmation of the importance of invariance of sound-symbol relationship.

It may be pointed out that the El Konin research dealing with a phonemically different language may not be directly applicable to the English language. Even though the Russian nyet-da is not strictly comparable with the English yes-no, the linguistic difference is one of degree rather than kind. Further evidence for the importance of rule acquisition is afforded from the apparently disparate Chinese language (Section 2.5).

This is not the place to go into the ramifications of the similarities and differences of alphabetic and ideographic languages in learning to read or not to read. The present writer has drawn attention elsewhere to the isomorphy between the apparently disparate systems (Leong, 1972b, 1973a) and have suggested strategies for comparative studies in early reading (Leong, 1971). Kolers (1970) is one of the few psychologists recognizing the possible commonality between the reading of English and of Chinese as an interpretation of symbol systems. Briefly re-stated, learning to read in English is largely learning by eye and ear. In a similar analogy, learning to read in Chinese is largely learning by eye and hand. Specimen Chinese characters and words in Figure 10-2 illustrate this. The character 中 by itself means centre, middle; so also in combination with 間 (sun 日 enclosed in two doors 門 meaning time, partition). The character 醫 (medicine, to cure) has three components meaning: (a) wound enclosing 匚 an arrow 矢 (医); (b) extracting foreign bodies with an instrument 殳 and (c) treating wound with tincture 酉 which is a variant of wine 酒 (tincture diluted with water 氵). The character 醫 in combination with 生 (to give birth as calf 牛 learning to stand up thus 生) means a physician. The illustration of the number and direction of strokes shows the balance and flow of each character--attributes to be mastered by hand. It is therefore no surprise that beginning readers in Chinese start learning to write early--and plenty of writing as well. Might this spaced and massed practice capitalizing on the eye-hand linguistic awareness of the language, and not so much the sheer philological nature of the language itself, provide a possible clue to the kind of provocative statement made by Makita (1968) about the rarity of

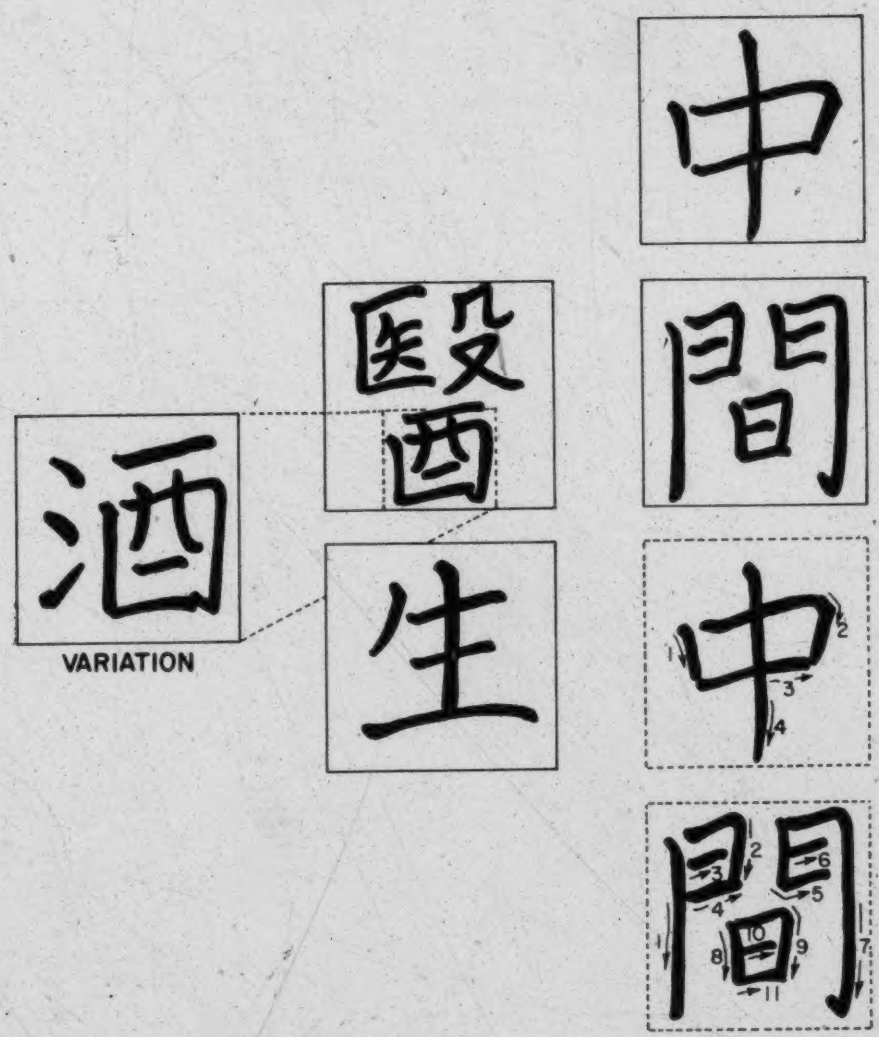

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Figure 10-2. Illustration of an orthography best learnt by eye and hand--Chinese. Reading is from right to left, top to bottom. Note the symmetry and rhythm of the characters. Those enclosed in dotted lines also show the flow of the strokes.

reading disability in the cognate Japanese language? The importance of segmentation is also evident from the bipartite or tripartite division of the characters as shown. Suffices it to say, the two cardinal principles of linguistic structure built on the logical contradistinctions of "markedness-unmarkedness" as in distinctive features and "variance-invariance" of morphophonemic and syntactic rules (Jakobson, 1972), obtain across language boundaries. The markedness-unmarkedness dimension may take the forms of voicing and unvoicing in the English language, harsh-soft sounds in Russian, rising-falling tones in Chinese; but the invariance is always there. The variance-invariance dimension implies knowledge of systematic (near one-to-one) relationship between phonological segments and letters and clusters of words and grammatical series and a residue of exceptions or irregularities. It is the same combination, in some optimum form, of order and randomness that characterizes another form of language--music. Beethoven is said to have remarked that in music everything must be at once surprising and expected. If too little is surprising the lines are boring; if too little is expected, the lines are abstruse and the listeners frustrated. These apparent contradistinctions or complementary-different attributes of markedness-unmarkedness and variance-invariance and their applications to beginning reading in alphabetic and ideographic languages are the subject of a forthcoming paper by the present writer (Leong, in preparation, 1975).

10.3 Maturational Lag in Cerebral Development Further Considered

From the re-affirmation of the efficacy of research findings it is timely to re-examine first the basic premises of maturational lag in cerebral development and later simultaneous-successive information-processing in children with specific reading disability.

Money's (1966, p. 34) call for neuropsychological investigation is apposite:

> The great majority of reading disability cases will be classifiable not on the basis of brain pathology; but simply as representative of a lag in the functional development of the brain and nervous system that subserves the learning of reading.

The rationale of the maturational hypothesis is stated in Section 2.6.3; the theoretical framework in Chapters 3 and 4; the basis of testing in Sections 5.2 and 5.3 and the formulations and results are found mainly in Chapters 6 and 7. To tie all the above theorizing and empirical results together, some brief comments will be offered.

First, in keeping with Critchley (1964, 1970), Geschwind (1962), Money (1966) brain damage cannot be implicated in specific reading disability. This, however, does not rule out the incidental co-occurrence of structural damage and dyslexia in an individual case.

Secondly, the formulation of maturational lag in cerebral development postulating differential maturation of tasks from sensori-motor to the more complex and integrated intellective ones holds the attraction of being consonant with the positions of developmental psychologists (Hunt, 1961; Piaget, 1926). The present investigation focusing on cerebral lateralization of speech verified through dichotic listening materials together with the examination of factorial structure of some "non-reading" tasks provides some evidence on a cross-section of dyslexic boys. These children compared with their normal reading counterparts equated on age, sex and ability level do show impoverished results in dichotic speech perception and less well developed right-ear effects. Some longitudinal results are provided by Satz and associates on children of different age groups (Satz and Sparrow, 1970; Sparrow and Satz, 1970; Satz and Van Nostrand, 1973). It is indeed found that 7- to 8-year-old disabled readers are more impaired in sensori-motor tasks while 9- to 12-year old dyslexics are more disabled in conceptual tasks. The keynote in both the present and the Satz investigations is that "retardation" is in the acquisition of various skills rather than in the loss of abilities. Thus the Satz studies validate the much earlier suggestion by Benton (1962) that perceptual deficiencies are found more in younger retarded readers and that conceptual deficiencies are found in older retarded readers. The perceptual and conceptual aspects, however, merge imperceptibly as even perceptual tasks are verbally mediated and require for their successful performance a large conceptual component. The conceptual explanation will follow in subsequent sections.

Thirdly, the maturational lag formulation carries the implicit assumption that disabled readers considered as individuals may show a slight increase in sinistral tendencies without implicating the left-ear effect as indicative of reading disability. There is some circumstantial evidence for this from the inspection of right-left dichotic scores for individual children in the present investigation. Theoretical and empirical supports come from recent studies by Annett and associates (Annett, 1970, Annett and Turner, 1974) and from Studdert-Kennedy and

Shankweiler (1970). Annett (1970) stresses that lateralization of speech is a matter of degree and may take several forms intermediate between strong preference for one side or another. The Haskins group emphasizes that:

> The absence of an ear advantage is not inconsistent with complete lateralization of some portion of the perceptual function, since the outcome may simply indicate that the acoustic materials being studied are not susceptible to information loss under certain experimental conditions.
>
> (Studdert-Kennedy and Shankweiler, 1970, p. 592)

This exposition seems to offer a further rapprochement of the perceptual and memorial processes in dichotic listening tested in the first experiment (Section 7.2). The assertion that the left-ear effect does not accentuate reading disability is a logical extension of the view of Orton (1925, 1937) on handedness. The view is well re-phrased by Bakker (1973) who suggests that the child who is clearly left-eared will not encounter much more difficulty in learning than the right-eared. The subsequent derivative of Bakker (1973) that "reading ability correlates positively with the absolute values of the between-ear difference scores, be they positive or negative." (p. 16, author's italics), is provocative and requires further substantiation. It is doubtful if the size of the right versus left or left versus right scores should be exploited in this way (Studdert-Kennedy and Shankweiler, 1970). The subsequent main thrust by Bakker that cerebral dominance interacts with the learning to read process and that every stage in this process is characterized by an optimal lateralization pattern deserves much careful attention. It may well be that the relationship between lateralization and reading ability or stages of reading is a non-linear one. In severely disabled readers there is a monotonic relationship between the two variables and once one has reached a moderate level of reading ability the relationship is a curvilinear one. The cautiously stated rider that "it is even possible to think that early reading profits by a bilateral representation of functions" (Bakker, 1973, p. 17) may apply in some cases. This seems to echo the earlier and equally cautious view stated in the obverse by Geschwind (1962) that bilateral mal-development of the angular gyrus would be the minimum substrate for difficulty in learning to read. Bilateral according to Geschwind because of the tremendous ability for the nervous system of the young child to find alternative means of compensating for dysfunction to localized areas. Might not the bilateral representation suggested by Bakker explain the impaired performance of the present experimental group in the non-reading tasks as well? In any case, the Bakker explanation can be accommodated within the hypothesis of lag in cerebral maturation.

Fifthly, the implied hereditary predisposition in the maturational lag approach (Sparrow and Satz, 1970) finds some support, albeit shadowy and diffused, in the subsidiary study of case histories in the present investigation (Sections 9.2 and 9.3). It must be pointed out that multiple cases of reading disability existing in the same family do not necessarily suggest, let alone prove, inheritance as various members are subjected to similar environmental stresses and strains. Only intensive clinical studies, particularly involving twins, can elucidate this (see also Section 2.2).

Sixthly, lest the implied hereditary predisposition sounds nihilistic, it must be reiterated at once that the developmental rather than the disease model (Satz and Van Nostrand, 1973) suggests possibilities of treatment. This should be of certain intensity, given in good time and suited to the individual child (Section 9.4). Subsequent discussions on information-processing strategies will further clarify this aspect.

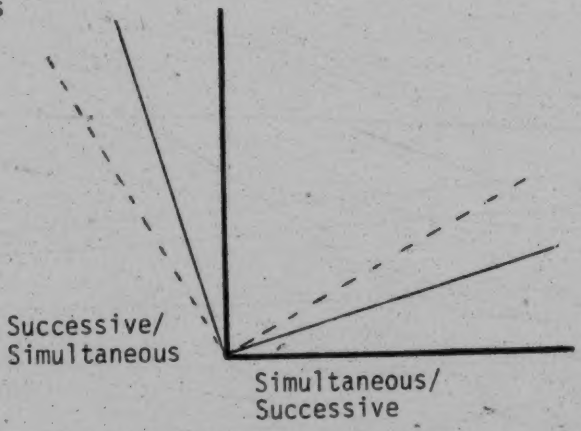
10.4 Simultaneous-Successive Syntheses Re-Interpreted

In the present investigation, just as the premise of functional cerebral development is tapped mainly by the dichotic experiments, so the Luria paradigm of simultaneous-successive syntheses operationalized by Das is tapped mainly by the spatial-temporal tasks. As will be further shown, the dichotic tasks also bear on the simultaneous-successive dimensions while the two-dimensional matrix affords another explanation of the convergence of dichotic listening materials.

The rationale of the Luria paradigm is explained in Section 4.4 and will not be repeated here. Suffices it to say that Das (1972a, 1972b, 1973a, 1973b) in his series of studies has demonstrated that two main components, one he terms simultaneous and the other successive, have consistently emerged from his basic tasks. Without loss of generality, similar dimensions (cutting across components and factors with the respective component and factor analyses models) have been found, group for group, for the variant version of the Das battery and also with the dichotic tasks added (Chapter 8). It is therefore reasonable to assume that there are statistical and psychological realities to the simultaneous-successive dimensions. This logical reasoning, however, must be tempered with reference to the battery of tasks used, the composition and the size of samples studied. The statistical findings need to be further validated with tasks spanning the gamut of "memory" and "reasoning" including creativity; tasks varying in complexity; younger and older age groups than the age range of 6+ to 9+ used thus far; larger sample size than the N≏60 in the present and other investigations and variant factorial models of analysis than the principal component and alpha factor analyses used by the present writer. Then there are the questions of the precise relationship between simultaneous-successive syntheses, Jensen's (1969) Level I and Level II abilities and the ubiquitous serial and parallel processing which has figured so prominently in the relevant literature. Replications along these lines will greatly enhance our understanding of the Luria-Das simultaneous-successive information-processing. This cautious approach is in line with Broadbent's (1971) plea for exploring alternatives in experimentation. Given the statistical realities of the simultaneous-successive dimensions it seems more fruitful to conceptualize these as forming the coordinates in a two-dimensional information space. Hence the preference throughout this treatise for the conjoint term "simultaneous-successive syntheses" or "simultaneous-successive matrix" to signify the togetherness rather than separateness of the related dimensions. This unifying approach is a more flexible conception and is supported by arguments from at least four sources: statistical, epistemological, psychological and neuropsychological. Each of these perspectives will be brought out in turn.

10.4.1 Statistical Reasoning

In factor analysis, the factor loadings constituting the simultaneous-successive dimensions represent correlation coefficients between the variables and the factors. A loading is a weight for each factor dimension measuring the variance contribution the factor makes to the data vector. In the present investigation loadings are distributed in a two dimensional information-space bounded orthogonally by the dimensions termed the simultaneous and the successive as shown in the thick solid lines. In factor analytic terminology, it matters little whether the horizontal axis denotes the simultaneous or the successive; or the vertical, the successive or the simultaneous so long as the simultaneous-successive coordinates define the vector space. Again, in factor-analytic jargon the coordinates can be rotated to the positions shown by the thin solid lines and the dotted lines and the relative positions of the loadings still maintain. Yet again, in keeping with the basic tenet of factor analysis, the dimensions extracted relate to the tasks used and the a priori assumptions made. It is therefore not to the point to ask if the dimensions are hierarchical or parallel. Statistically, they may be orthogonal or independent for unselected populations. Psychologically what is simultaneous and what is successive are relative within the matrix postulated.



The apparently simple explanation above of the interchangeability of dimensions, one that often overlooked, finds support in the classic factor-analytic work of Thomson (1951) and the recent elegant conceptual explanation of determinacy of factors by the statistician Maxwell (1972a, 1972b). Very briefly, Thomson conceives of the mind as consisting of a large number of components or bonds a proportion or sample of which only is required for the performance of a given task. Statistical correlations between tests are thus due to sampling from a common pool of elementary units or "bonds." As people differ in abilities and in the ways they process information, and as tests differ in nature and complexity; different "bonds" in various combinations and proportions are required in the successful performance of these tasks. As Thomson puts it, the "comparatively undifferentiated complex of innumerable influences" must not be taken to mean the localization of brain functions, as he is well aware of their inter-relatedness and complexities. Within this framework of "sampling bond" theory and from his empirical factor-analytic studies, Maxwell reinforces Thomson's notion of factors as statistical concepts and warns against reifying factors as "immutable entities in the brain." He further demonstrates that the determinacy of factors derived from the efficient and elegant maximum likelihood method demands the use of relatively short tests with a "singleness of purpose" while the tests as a whole covering a wide spectrum of abilities. Only thus will factor analysis throw light "on the possible organization and functioning of mental processes" (Maxwell, 1972a, p. 9).

Maxwell's re-consideration of Thomson's theory from both the mathematical and psychological aspects is salutary and is consonant with current theories of complex brain functional systems (Chapters 3 and 4). Results from the present correlational studies of the main simultaneous-successive dimensions and their invariance across methods of intra-group analyses (Chapter 8) gain further credence in this light. The difference between groups for the constructs as shown in Schonemann factor matching can be accounted for by evoking a similar explanation of Maxwell (1972b). It has been pointed out that inspection of the correlational matrices of the experimental and control groups shows a slight difference. The serendipitous finding by the present writer of a method of testing for the equivalence of two correlation matrices by Jennrich (1970) came late in the investigation to be applied. Two plausible explanations based on Thomson's theory are offered to account for the difference in the size of the correlations and the consequent lack of statistical equivalence in the factor patterns of the Experimental and Control Groups. One possibility is that the disabled readers on an average employ larger proportions of the basic units or bonds in answering the tests; another possibility is that they may sample from a restricted range of the bonds. In any case, both explanations portend an inefficiency in information-processing strategies. This explanation has the attraction of steering clear from regarding the dimensions as being rigid and immutable, and draws attention to individual differences inherent in both tasks and children. The significance of the efficient use of information-processing strategies will be unfolded in subsequent sections.

10.4.2 Epistemological Reasoning

The demonstration from statistical reasoning of the interchangeability and flexibility of the simultaneous-successive dimensions within an information space finds support from epistemological sources. To revert to the flowchart of Figure 1-1 setting forth the rationale and sequential steps of the present investigation, it can be seen the mainstay of the three dichotic experiments involve the perception of speech while the other mainstay of simultaneous-successive tasks are mostly spatial or temporal. Notwithstanding the usual notion of speech as being primarily sequential, successive; attention has been drawn to the underlying complex and simultaneous nature of language stimuli (Section 2.6.2, Chapter 4, Section 5.3). Thus Jakobson (1967) the linguist speaks of the non-linearity of speech; Broadbent (1958, 1971) the experimental psychologist of information space in speech perception; Luria (1966a, 1966b, 1973) the neuropsychologist of the selective multi-dimensional matrix and the Haskins group (Cooper, 1972; Liberman, 1970; Liberman, Cooper, Shankweiler, and Studdert-Kennedy, 1967; Mattingly, 1972) of the parallel transmission of the successive processing of units at the word, phrase or sentence levels. These convergent views of the primarily successive nature of speech stimuli nested in a complex spatial matrix should be borne in mind in interpreting the dichotic experiments and in accommodating the simultaneous-successive syntheses borne out of temporal and spatial tasks.

From the epistemological point of view the notion of succession or sequentiality implies the parallel or the simultaneous. The very concept of time suggests moments of change. The etymology of the word time in French means successive states of the weather, in Latin the double meaning of time and rhythm, and in Sanskrit to burn (rhythm of day and night) and in Chinese 間 (the sun behind a door) in Figure 10-2 again means succession, change with the attendant rhythms. All these point to Aristotle's dictum that time does not exist without changes. Kant's notion that time is not a copy of things but a way of considering them paves the way for psychologists to consider time in the activity of the mind. Thus, what appears to be the obvious may be restated. Time is successive and dynamic. The perception of evanescent, temporal elements depends on their orderliness, their rhythm and the temporal intervals separating the elements. This finds an exposition in a charming but much neglected book by Fraisse (1964). Quoting Bergson, Fraisse (1964, p. 70) draws attention to the fact that perception of succession implies the simultaneous, not successive, perception of before and after. We apprehend successively because we project that being perceived in space and make the end of the first state coincide with the beginning of the second. When stimuli are numerous, rapid and regular, we perceive succession because of "subjective patterning" in grouping the elements into twos or threes. Thus the grouping is the result of simultaneous apprehension of several elements which form one unit of perception.

The apparent paradox of the successive interpreted in the context of the simultaneous can be illustrated from the natural phenomenon of lightning. It is lightning produced by the discharge of electricity from a cloud which causes the sudden vibration of the air to take place at the same time; but in our perception the thunder follows the lightning. Similarly, flashes of lightning may appear to be simultaneous whereas the flash which is nearer (proximal) to the observer actually takes place after the flash farther away (distal). Drawing on some early work on perception, Fraisse (1964, p. 107-108) states that

> True perception of simultaneity cannot take place unless the stimuli can be integrated or unified so that we apprehend them together without having to divide our attention. Inversely, whenever this unification is difficult, the perception of simultaneity is very unstable.
>
> (Author's italics)

He further explains (Fraisse, p. 286) that simultaneity involves seriation and duration and that

> . . . when two perceptions are simultaneous, it does not necessarily mean that the two events to which they correspond are also simultaneous. It all depends on the position of the observers in relation to the sources of the phenomena and the speed of transmission of the messages.

For those skeptics who may cast doubt on the above phenomenological explanation of time perception, attention should be re-directed to Section 4.3. There the notion of temporal order perception with particular reference to exceptional children is expounded. From his critical review of acoustic and psychologic sources, Fay (1966) shows that successiveness can be perceived within a range of 15-20 msec., although the usual range of 50-60 msec. is required for inexperienced observers to identify the order and succession of stimuli (see also Efron's reaction to Hirsh, 1967). On the other hand, Efron (1963a, 1963b, 1963c), demonstrates from a series of experiments that when simultaneity of temporal stimuli is claimed, the stimulation on the left ear should precede the one on the right ear by about 3.5 msec. Thus, in effect what is considered or perceived as simultaneous is strictly one of succession separated by rapid intervals. This little realized, albeit very refined, empirical demonstration is in line with the exposition of auditory perception and cerebral specialization in Section 3.7 (see also Figure 3-3) and vindicates the phenomenologists. In this context, Bakker's (1972) interesting account of temporal order perception in relation to hemispheric specialization also deserves attention. The simultaneous-yet-successive finding thus adds to the force of the interpretation of the simultaneous-successive constructs as flexible, interchangeable dimensions.

10.4.3 Psychological Reasoning

The above flexible interpretation of the underpinning of simultaneity to events which are essentially successive is reinforced by an even closer scrutiny of the dichotic listening paradigm. From the exposition in Chapter 3 and Chapter 4 it can safely be assumed that by their very nature dichotic listening experiments require the simultaneous input of stimuli and the successive output in verbal reporting. In addition to tapping central processing, the very precise experiments provide the most efficient means of delineating the nature of simultaneous-successive matrix. The exposition in Section 5.2 of the Broadbent filter theory underlying dichotic experiments has alluded to the need for broader interpretations. The original Broadbent model of 1958 postulating parallel processing in the S-System of sensory registration but serial processing at the P-System (Figure 5-1) needs to be broadened to accommodate other viable alternatives.

Contrary to or rather complementary to the filter theory, there is some recent evidence that parallel processing of simultaneous inputs is possible. This is shown by Treisman (Treisman, 1970; Treisman and

Fearnley, 1971) in some important tasks involving the presentation of pairs of precisely synchronised auditory items (nonsense syllables or a nonsense syllable and a digit). Using a probe technique (Section 10.1) and with precuing the subject was asked to press a key if one of the items was a digit and another key if neither was a digit and his reaction time was measured. It was found that the decision about neither of two simultaneous items is a digit could be made in parallel for the two items. It should, however, be added that the efficiency of parallel processing is less than the efficiency of processing single items. From the Treisman studies there seems to be no single-channel bottleneck in the perceptual system. A slightly different interpretation of the filter theory is given by Moray (1967). Without abandoning the concept of limited channel capacity, he suggests the total capacity of the brain can be allocated to the separate aspects of the tasks such as reception, recording, storing, etc. This explanation is more in line with the differential use of information-processing strategies to be further explained. His subsequent time-sharing theory (Moray, 1969a, 1969b) of a filter alternating very rapidly between channels so long as no stimuli of special significance are detected presents some difficulty in the role it assigns to the timing of stimuli: if two auditory stimuli are presented in slight asynchrony, the one presented first should always be detected. In fact, research findings from the field of psychoacoustics points to the otherwise effect of a slight time lag. Berlin et al (1973) find when the left ear receives messages 30 msec. later than the right ear, both ears perform as well and that in general it is the lagged CV's trailing by 30-60 msec. that become more intelligible.

(Berlin et al, 1973; Studdert-Kennedy and Shankweiler, 1970). From these theoretical discussions of parallel and serial processing in dichotic listening it is fair to say that dichotic inputs must, at some point in their time course, converge on a final common path in the nervous system. The Haskins group (Studdert-Kennedy and Shankweiler, 1970) suggests convergence of the two signals in the dominant hemisphere occurs before the extraction of linguistic features and that it is for this process of feature extraction that the dominant hemisphere is specialized. In the brains-machines analogue of information-processing (Section 4.1) the ultimate importance must lie in the study of the human nervous system (Broadbent, 1971, p. 478).

10.4.4 Neuropsychological Reasoning

To round off the exposition of the more flexible simultaneous-successive syntheses, it is essential to return to Luria's work (see also Sections 3.3 and 4.4). Careful re-examination of Luria (1965a, 1966a, 1966b, 1970a, 1970b, 1973) shows his cautious approach to the "conventional" terminology of simultaneous and successive syntheses which "are not sufficiently accurate" and his implicit assumption of a complex matrix embodying these syntheses. In the first place, he explains that by simultaneous synthesis is meant the "synthesis of successive (arriving one after the other) elements into simultaneous spatial schemes" and by successive syntheses is meant "the synthesis of separate elements into successive series" (Luria, 1966b, p. 74). The former process is characterized by "surveyability" while the latter by "order" and "kinetic melody." These characteristics are close to the "logical multiplications" to be discussed in Section 10.5 and to the orderliness and rhythm expounded in Section 10.4.2. More importantly, through his exposition, Luria speaks of "integrative activity" and "analytico-synthetical" activity of the cortex to show the inter-relatedness of simultaneous-successive syntheses. He makes it clear that in speaking of modes of information-processing he only underlines that aspect which is of chief concern in a particular investigation (Luria, 1966b, p. 83). The following quotation explains aptly the wholistic and localized "complex functional systems" of the brain working in concert:

> that syntheses of elements into simultaneous groups and successive series may form a part of any analytico-synthetic activity and are two forms of working of the same brain structure, two necessary aspects of each neuro-dynamic process. The nervous processes constituting the work of any analyzer always take place in time and are always dependent on certain spatially organized structures. The correlation of dynamics with structure, . . . would be impossible without taking into account both these aspects of nervous activity. [p. 79]

These complementary-different functions reflect current views of cerebral mechanisms (Chapters 3 and 4). One is also reminded of the statement by Lashley (1951) that spatial and temporal order is interchangeable in cerebral action (Section 4.2). In passing, it strikes the present writer that the terms "verbal-logical" and "concrete-active" used recently by Luria (1973) and reminiscent of the British v:ed and k:m factors of the mind merit consideration. Just as "simultaneous syntheses" and "successive syntheses" explain some underlying constructs, "verbal-logical" and "concrete-active" also have a ring of realities. The apparently contradictory concrete-active syntheses both describes and explains the basically successive tasks. The verbal-logial is not confined to overtly verbal materials and is the basis of operation on such drawing tasks and matrices, as will be shown in Section 10.5.

Summarizing, the two correlational studies as well as the dichotic experiments re-affirm the realities of the dimensions of the simultaneous and the successive. It is suggested that a more flexible interpretation would be to regard the dimensions as coordinates of a two-dimensional information space. Psychological reasoning from at least four sources--statistical, epistemological, psychological and Luria's own neuropsychological studies--provides support for the more dynamic simultaneous-successive matrix. Statistical with regard to the nature of factor analyses and Thomson's sampling bond theory; epistemological from the paradox of succession interpreted in the simultaneous context; psychological from the difficulties of determining parallel and sequential information transmission and pick-up even in the precise dichotic experiments; neuropsychological from the integrative nature of analytico-synthetical activities.

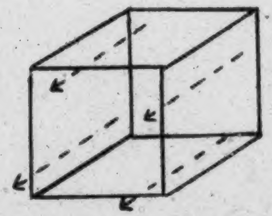
With the postulate of maturational lag in cerebral development and the operationalization of the dichotic experiments, some insight into hemispheric specialization is gained. With the more fluid interpretation of simultaneous-successive syntheses, parsimonious information is afforded on the underlying constructs of some tasks spanning areas of memorial and conceptual domains. There are still many unanswered questions. These pertain to the role of the input-output flow of information, the role of different modalities particularly the visual-auditory and if the simultaneous-successive matrix relates more to one communication process, one sense modality more than the other; above all the specifics of the processing of spatial-temporal information by young children in general and by dyslexic-rich children in particular. It is to this last-named question that the next section will address itself.

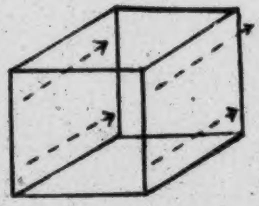
10.5 Strategies and Tactics in Information-Processing

In order to answer the question how children in the two groups process information it is essential to go back to some of the tasks (see also Section 6.4) and to examine their contents. It is imperative to observe and deduce the strategies and tactics the children use to operate on these tasks. In this context, the term strategies refers to the selection of one from a number of possible alternatives and the creation of a general plan or scheme for the performance of a task. By tactics is meant the appropriate methods and operations required to put the general scheme into effect.

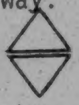
Take as an example what appears to be a straightforward task of copying geometrical figures--the Figure Copying Test. Further comments will be offered in addition to those in Section 10.1. From the developmental point of view, one would expect the task to be relatively easy for nine-year-old children. It is therefore all the more perplexing to find the Experimental Group trailing behind the Control Group when these two groups are equated for age, sex and ability, and given the "non-reading" nature of the task. There is thus further evidence for the postulate of maturational lag in cerebral development. But to attribute this lag as resulting in slower visual perceptual or motor abilities in the copying task is only part of the answer. The full answer must be in cognitive terms: in terms of the grasp of the "field," the identification of critical feature and the knowledge of essential rules for the successful execution of the copying of figures.

Developmentally, the ability to copy figures follows a certain order: 3-year-olds can draw circles; 4-year-olds, squares; 5-year-olds, triangles; and 7-year-olds, diamonds. The nature of this ability is variously explained. Gestalt psychologists (e.g., Wertheimer, 1957) speak of restructuring the field, of structural laws of "integrity" and "prägnanz"; cognitive psychologists stress feature analysis and the detection of distinctive features (Gibson, 1969; Maccoby, 1968; Neisser, 1967; Olson, 1970). The failure in copying figures can be explained in terms of Arnheim's (1972, p. 303) "character of the dynamic vectors" and Luria's (1973, p. 331) overcoming the "vectors of direct perception: and of "*converting the elements of impression into elements of construction*." (author's italics). This is illustrated on the right. There is some evidence for this on closer examination of the drawings (see sample drawings in Figure 10-1) of the children. They see the two cuboids (items 9 and 10 of Figure Copying Task) in particular as oscillating between two mutually exclusive versions. This failure is explained by Maccoby (1968) as due to a failure in discriminating sufficient distinctive features. In this case or with Figure 10-1 it would be the inability to perceive the drawings as cuboids from





different perspectives and with corresponding properties. On the positive side Olson (1970) has shown teaching construction rules results in significant improvements in copying diagonals.

There one has it. From observation some children actually found it difficult to tackle the copying task in a systematic way. One child, for example, copies the rhombus as two triangles thus  and then erasing the 2 base lines. While quantitatively he is right, qualitatively he shows insufficient grasp of the pattern and also inadequate constructional schemata. Thus, while the component/factor analyses show the Figure Copying Task loads on the "simultaneous" dimension, this probably refers to the input stage. The pattern is perceived as a structured whole. In order to create a drawing that represents the model, the child must recognize segments or critical features, appreciate the relationship between segments and the whole and then use this knowledge to reconstruct this relationship. This kind of meaning is probably what leads Maccoby (1968) to suggest that drawing is necessarily a sequential process. Whatever the underlying construct is, it is certain that adequate visual analysis is a necessary but not sufficient prerequisite to the production of accurate copies (Rand, 1973). Visual configuration and details will largely delimit the drawing task; knowledge of drawing rules determines the ability of the child to reconstruct the relationship of details and also the quality of the drawings.

The Figure Copying task is commented on at some length partly because it is sometimes assumed, and naively, that it is a simple task. As a prototype of other visual-motor tasks, the remarks made here and in Section 10.1 apply with equal force to other tasks in the same group such as the Memory-for-Designs test.

To summarize, it is fitting to invoke the observation of Piaget and Inhelder (1956) on the child's conception of space. They state that the failure of the child in the general conception of space is related to a failure in establishing euclidean relationships (co-ordinate system) and a failure to co-ordinate projective viewpoints as perspectives, sections, projections and place locations. Both the euclidean and projective systems provide the framework for logical multiplication (Piaget and Inhelder, 1956, p. 423) so essential to cognitive processes. Their suggestion (Piaget and Inhelder, 1956, p. 418) that the age of 9 or thereabouts makes a "decisive turning point in the development of spatial concepts; that of the completion of the framework appropriate to comprehensive euclidean and projective systems" and also the completion at about the same period of another "great comprehensive system--that of time, co-ordinating movements and speeds" further vindicate the postulate of developmental lag in cerebral development. What is little understood is whether it is this lag in functional development which "causes" the inefficient use of strategies and rules and whether it is the other way around. In the absence of evidence, it is not to the point to discuss cause-and-effect. Rather, one can say the maturational lag and inefficient information processing co-exist or are co-incidental. As a social scientist, one might hope that the improvement in the use of strategies and rules may provide the favourable environment for cerebral growth.

The logical multiplication principle of Piaget and Inhelder (1956) brings us to Raven's Coloured Progressive Matrices (Raven, 1947a). It is a non-verbal analogy test usually attributable to Spearman (1927) although the latter ascribes the origin of analogies test to Burt (Spearman, 1927, p. 201). In the context of the early growth of logic in the child, Inhelder and Piaget (1964, pp. 151-154) speak of the Raven's tests as an example of "multiplicative classification" which is mastered at about ages 8. By multiplicative classification is meant "classing each element *simultaneously* in terms of (the) two additive orders" (authors' italics). The authors give the example of a set of elements (e.g., red and blue squares and circles) which can be divided into class A_1 and $A^1{}_1$ according to one criterion (e.g., A_1 = squares and $A^1{}_1$ = circles) as well as into two difficult classes A_2 and $A^1{}_2$ on the basis of a second criterion (e.g., A_2 = red elements and $A^1{}_2$ = blue elements). If we let $B_1 = A_1 + A^1{}_1$ and $B_2 = A_2 + A^1{}_2$ then $B_1 \times B_2 = A_1A_2 + A_1A^1{}_2 + A^1{}_1A_2 + A^1{}_1A^1{}_2$. The four-way classifications yield a 2 x 2 matrix as follows:

	A_1	$A^1{}_1$
A_2	A_1A_2	$A^1{}_1A_2$
$A^1{}_2$	$A_1A^1{}_2$	$A^1{}_1A^1{}_2$

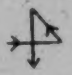
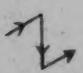
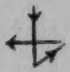
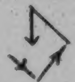
In an extended scheme for the presentation of test items, the formal structure could be rendered more complex and yet at the same time be impressionistically perceived (Burt, 1911, 1937). The general principle could be schematically represented as follows:

$$\begin{array}{lcccc}
\ldots & a_1b_1 & \vdots\; a_1b_2 & \vdots\; \ldots & \vdots\; a_1b_m \\
\ldots & a_2b_1 & \vdots\; a_2b_2 & \vdots\; \ldots & \vdots\; a_2b_m \\
 & \ldots & \ldots & \ldots & \ldots \\
\ldots & a_nb_1 & \vdots\; a_nb_2 & \vdots\; \ldots & \vdots\; X?
\end{array}$$

Where a_1 and b_2 denote two essential aspects of the test items such as shape, colour, line, position and the like which change systematically step by step. With small geometrical figures as a basis, a variety of problems with progressive degrees of elaboration can be compiled.

From the short exposition, it can be seen the Progressive Matrices Test is a fairly complex one requiring for its efficient solution elementary notions of multiplicative inclusions symbolized by matrices or by topological geometry. Two questions may well be raised at this point. One pertains to the notion of simultaneity as mentioned by Inhelder and Piaget (1964) and as a construct derived from the component/factor analyses in the present correlational studies in line with the findings of Das (1972a, 1972b, 1973a, 1973b). The other relates to the differential performance of the equivalent groups given the nature of the task. These two questions can be answered together. The notion of simultaneity more likely refers to the scanning, the grouping of the elements during the input stage. It is likely that the child has to "hold" the elements and the groups temporally, internalize them and come to some decision as to which of the "bits" completes the pattern. This seems to be the likely strategy as it is difficult to find out exactly how the child performs the task. On the question of the wide variation in group performance, one indirect answer may be that measured intelligence, whether on the Lorge-Thorndike Non-Verbal of the WISC Performance Scale, does not adequately tap an individual's "capacity to form comparisons, reason by analogy" as the manual claims for the test (Raven, 1968). But there is more to the task than explained by the partial answer. The child does poorly on the Raven's because he is using a poorer strategy--

one of perceptual factors or what Inhelder and Piaget (1964) call "graphic collections." The spatial configuration of parts of the whole and their symmetry easily lead the child to solve each problem by comparing similarities and differences in operational structures rather than resorting to the more efficient prelogical and logical relationships shown in the matrix schema earlier. In fact, almost the whole of Set A can be solved through "graphic collections", (hence also the lack of discrimination of this set as reported in the literature). Some children in fact were puzzled by the less obvious analogy items as to what was required of them. While this to some extent is the weakness of the task, it also reflects the possibility that given the strategies, rules, the children in the Experimental Group might have done better.

At this point, one may well pause and go back to the results of the correlational studies. The two tasks further discussed in this section together with the cognate Memory-for-Designs have been found to load on the simultaneous dimension. This has been interpreted in the broader and more flexible context of the two dimensional coordinates of simultaneous-successive syntheses. While it is difficult to ascertain the internalized process of the child, what is simultaneous seems to be more characteristic of the information intake. In particular, simultaneous-successive syntheses gains meaning in the framework of efficient use of strategies, rules and repertoires of stored information. One may well ask about the place of the third "unique" dimension--sometimes identified with the Visual Short-Term Memory task for the Experimental Group and sometimes with the ITPA Visual Sequential Memory subtest for the Control Group--and also the more elusive Auditory-Visual Coding straddling the simultaneous and successive dimensions. On the "unique" third dimension a global explanation is that the nature of the tasks is such that they do not provide for a coordinate framework of order and dimensionality. Conversely, the children find it hard to use a particular set of rules. With the ITPA Visual Sequential Memory subtest this lack of a framework is probably confounded with the ceiling effect for the Control Group. With the Visual Short-Term Memory task the tripartite operation of scanning the grid followed by the colour-naming interference task and subsequent recall probably disturbs the equilibrium needed in solving the task for both groups, but more so for the disabled readers. In the initial scanning process some disabled readers failed to use a consistent strategy in scanning the grid (Appendix L), which could be: , , , , or any other efficient method. Some also seemed confused by the interference task and were in complete disarray at the recall stage. Whether this failure to come to grips with the task and to apply some efficient strategy or within the framework of simultaneous-successive syntheses may account for the "uniqueness" of the dimension has yet to be further demonstrated.

A clue to the straddling of the Auditory-Visual Coding in the simultaneous-successive matrix may be found from a close examination of the nature of the task and the rules, repertoires and strategies required (see also Section 4.1 and 6.4(d)). Typically, the child hears patterns of sounds, he is then shown patterns of visual dots from which he has to select the one that corresponds to the auditory pattern of tones heard a few seconds earlier. This deceptively simple task is by no means simple as it involves at least these aspects:

(a) Attention to the task. This also includes selective attention to critical features. Selective inattention by gating out elements not needed for the repertoire may also be needed.

(b) Short-term memory. This implies the ability to switch from one task to the other.

(c) Knowledge of correspondence or equivalence rules.

(d) Efficient strategies in applying the correct rules.

It is little wonder that the generalized paradigm of cross-modal coding has been the subject of study in sub-humans as well as humans. The complexity of transfer has led the neuropsychologist Ettlinger (1967, p. 59) to assert that

> Cross-modal transfer of a specific discrimination habit may occur only with the aid of language, whereas cross-modal transfer of a principle and cross-modal matching may occur with or without the aid of verbalization.

Speaking of transfer by eye and hand, Rudel and Teuber (1964) suggest the unravelling of cross-modal coding will depend on finding stimulus properties that favours the hand or at least equally appropriate for eye and hand.

The intriguing problem of cross-modal coding and the strategies and tactics children use to perform the task is discussed in a series of fascinating studies by Goodnow (1969, 1971a, 1971b). The topic occupies a central place in a recent work dealing specifically with information-processing in a child development context (Farnham-Diggory, 1972). From these and other sources it can be argued if the transfer is one of modality effects. In the context of the present investigation one question that has to be answered is whether any cross-modal transfer effects are due to the visual and auditory modalities or whether the effects are due to spatial and temporal factors. The argument has been put forward that modalities are separate initially and development is seen as an integrative function (Birch and Belmont, 1964, 1965; Muehl and Kremenak, 1966). The trouble with this line of reasoning is that the nature of integrative function is not clear. Further, emphasis on modalities draws an artificially sharp line between intra- and inter-modal coding. The implication is that inter-modal coding is more difficult than intra-modal coding. There is, however, evidence to the contrary ~~from~~ studies with careful control made for both effects. Blank, Altman, and Bridger (1968), for example, found transfer from vision to touch but not from touch to vision. Bryden (1972) found intra-modal differences as great as inter-modal effects for auditory-visual tasks, while Milner and Bryant (1970) demonstrated intramodal tactual discrimination to be as difficult as equivalent cross-modal discrimination. Thus Goodnow (1969, 1971a, 1971b, 1972) argues forcibly, and quite rightly, for a more flexible explanation cutting across modalities and relating to the quality of performance of the child and his internal state. The quality of performance is related to these activities variously emphasized: scanning (Goodnow, 1969); serial order (Lashley, 1951); coding (Blank and Bridger, 1966; Blank, Weider, and Bridger, 1968); synthesizing stages of events and establishing equivalence systems (Farnham-Diggory, 1966, 1967, 1970, 1972). All these skills need to be used and integrated. Goodnow (1971a, 1972) provides some fascinating examples from the write-outs of young children in cross modal tasks. A nine-year-old child first paused physically to indicate "where you waited," then showed how he could do the coding in other ways: "(..) (..) (..); ../ ../ .. ; ..., ..., .. ; ../ ../ ..; and ..   ..   .. " Goodnow (1971a, p. 1195). To add to these charming examples, another boy said he remembered the auditory patterns like a song. This is what it should be! Thus the writeouts show various systems and a tendency to use variations in size and vertical space as well as horizontal space to represent divisions into segments.

These works of Goodnow and Farnham-Diggory are discussed at some length as they throw light on an apparently simple task and yet one which has been shown to be associated with reading disability (Section 4.1). These more recent works using the computer analogy have underlined the importance of rules, of strategies. These may account for the failure of the Experimental Group on this task and for the task straddling the simultaneous-successive matrix. Very crudely, the solution of the coding task in the correlational studies may include these steps:

```
DIMENSIONS -- PATTERNS OF TONES, PATTERNS OF DOTS,
              SHORT AND LONG PAUSES BETWEEN TONES,
              SHORT AND LONG SPACES BETWEEN DOTS.
    1.        ATTEND TO TONES, GATE OUT IRRELEVANT
              CUES; UNDERSTAND ORDER OF TONES
              (SUCCESSION);
              UNDERSTAND DIMENSION OF TONES
              (DURATION, RHYTHM);
              RETAIN ALL OF ABOVE;
              GØTØ 2;
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2       SCAN DOTS;
        UNDERSTAND ORDER OF DOTS;
        UNDERSTAND DIMENSION OF DOTS;
        RETAIN ALL OF ABOVE;
        G0T0 3;
3       ESTABLISH EQUIVALENCE RULES (USE
        REPERTOIRE);
        G0T0 4;
4       USE APPROPRIATE STRATEGIES
        (ALTERNATIVES);
        USE APPROPRIATE TACTICS TO OPERATE
        ON TASKS;
        STOP.
```

This very crude "computer programme" illustrates the complex operational steps involved in what appears to be a simple task. Note the notion of order, succession and rhythm propounded in Section 10.4.2 with regard to temporal events and the corresponding notion of spatial coordinates discussed in this same section. Thus sampling the properties of a stimulus--both its extent and order--provides a clue to the performance of the child. The extent of sampling may be restricted or extensive and the order may be in small or large steps, orderly or disorganized, consistent or inconsistent. There is certainly evidence both from observation of the children and empirical findings of their performance to substantiate these points. The heuristic theory of thought, which compares human thinking with the principles of operation of high-speed computers, is given by Simon and associates (Newell, 1972; Newell, Shaw, and Simon, 1958; Simon, 1962, 1969, 1972; Simon and Barenfeld, 1969, Simon and Newell, 1962). A fascinating exposition in non-computer language of the use of strategies and the development of the "processor" in problem solving of young children is provided by Simon (1972).

To sum up what has been said of the importance of strategies and tactics highlighted by cross-modal tasks, Piaget and Inhelder (1956) may once again be invoked. They stress the importance of "systems of reference" and state that ". . . a coordinate system or frame of reference presupposes . . . the topological notions of order and dimensionality" (p. 416). In spatial concepts, "a frame of reference is thus the product of logical multiplication applied to topological series . . ." (p. 417)

It is also fitting to point out that in the continuing dialogue between "brain and machines" (Section 4.1) and the fashionable computer analogue of human behaviour, even hard-nosed cognitive psychologists are coming to realize the need to study complex central processes in the context of child development and individual differences (Simon, 1972).

The view that knowing is knowing how and that knowing how is an integral dynamic act is certainly not new. It has been variously and forcibly stated in psychological literature. From his work dating from the 1930's Bartlett (1958) discusses "thinking within closed systems" and "adventurous thinking" and provides examples of novel experiments. In their important studies on concept attainment Bruner, Goodnow, and Austin (1956) have emphasized systematic strategies of search and hypothesis testing. Miller, Galanter, and Pribram (1960) speak of plans and "an internal representation, a model of the universe, a schema, a simulacrum, a cognitive map, an Image." Olson (1970) stresses alternatives and performatory acts in different media. Vygotsky (1962) suggests progression from a series of successive external actions (trials and errors) through extended internal speech to internal processes as the basis of mental operations. In his most recent pronouncement on neuropsychology within the grand design of psychological science, Luria (1973) draws attention to the "structure of thinking" and "systematic analysis" of neuropsychological activities as central to a clearer understanding of the cerebral mechanism of higher mental processes. There is also some reference to strategies and codings in the time explication of Bakker (1970, 1972); in the memory traces of Bryden (1967a) and in the "restructuring of modality order" of Senf (1969, 1972) (see Chapter 4). What is new is the stochastic structural approach of the Carnegie-Mellon group (Farnham-Diggory, Newell and Simon) and Goodnow. Their systematic analysis of the conditions of a problem and the choice of a system for many possible alternatives constitute the basis of their heuristics and provide better insights into information-processing.

That understanding of rules and their proper application is important in the solution of simultaneous-successive tasks runs parallel to the need for awareness, implicit or explicit, of morphophonemic and synthetic rules (Section 2.6.2) so basic to beginning reading. Thus the "non-reading" tasks and initial reading meet on a common front. The strategem explanation from one group of tasks reinforces that from the other and extends our knowledge of children with specific reading disability as an inefficient channel of communication.

10.6 Review

This chapter begins and ends, as with the others, in the spirit of scientific inquiry. This is well put by yet another social scientist ". . . the task of science is to discover not greater and greater similarity, but rather finer and finer differences" (Haywood, 1970, quoting McV. Hunt). It is clear that any evaluation of work preceding the present inquiry is meant as a tribute to those who have gone before.

With this quest for alternatives (if they exist) the integration of the theoretical considerations and experimental findings of the investigation is attempted. The synthesis begins with comments on the research designs, sampling, the nature and contents of some of the tasks. A strong plea is made for the careful, a priori selection of tasks. The efficacy of research into reading dysfunction is reaffirmed and specific researches are discussed to support the view of linguistic awareness. The postulate of maturational lag in cerebral development is further considered and found to be a viable proposition compatible with theories of child development and of neuropsychological findings of lateralization. The statistical realities of the simultaneous and successive dimensions are demonstrated. A more flexible two-dimensional coordinate system of simultaneous-successive syntheses is suggested as an alternative interpretation. The interchangeable system of the simultaneous with the successive is supported by four main areas of reasoning--statistical, epistemological, psychological and neuropsychological--with findings from the investigation buttressing the claim. Bestriding the theoretical consideration and empirical findings of functional cerebral development and simultaneous-successive syntheses is the understanding of a system of rules and tactics in information-processing. The development of strategies and the processes are seen as basic mechanisms in the greater understanding of children in general and children with specific reading disability in particular.

CHAPTER 11

RETROSPECT AND PROSPECT

Let these words answer
For what is done, not to be done again
May the judgment not be too heavy upon us.

T.S. Eliot, Ash Wednesday.

The statistician Tukey (1969, p. 88) once remarked that "no PhD builds his own cyclotron as part of the thesis. No PhD orbits his own satellite to get his data." While this is a plea for some conjoint investigation, it also reflects the restrictions of time, resources imposed on any researcher. And this one no exception.

Within these constraints the present investigation may be distinguished from the others by focusing attention on some psychological aspects of a narrow age group of boys with specific reading disability compared with an equivalent group of above-average readers equated on age, sex and ability. The investigation is at one and the same time a critical evaluation of some current theoretical considerations underpinning specific reading disability drawn from diverse but related sources--psychology, neuropsychology, speech perception and education--and an empirical investigation consisting of experimental and correlational studies based on two major premises. These are the formulations of functional cerebral development tested via the dichotic listening paradigm and simultaneous-successive syntheses verified through some "non-reading" tasks including dichotic materials. The three dichotic experiments throw some light on the postulates of the speech lateralization effects (for groups, half-spans and series lengths); the interwoven memorial and perceptual processes; differential strategies in reporting dichotic stimuli by sides (ears) and by types (digits and letters); and the differential recall of digits and letters of the alphabet. The two correlational studies provide confirmation for the statistical and to some extent psychological realities of the simultaneous-successive syntheses of information-processing.

To further cement the basic concepts and empirical results some broad case studies are offered to illustrate individual differences and to reconcile the perennial "towards generalization" and "towards uniqueness" approaches. In the general discussions comments are made on the research designs, sampling and tasks, while affirming the role of research into reading dysfunction. The formulation of maturational lag in cerebral development is further considered and found to be viable. A more flexible re-interpretation is offered for simultaneous-successive syntheses with reasoning from statistical, epistemological, psychological and neuropsychological sources. From a re-appraisal of the theoretical constructs and careful observation of performance of the children in various tasks, a viable integration of the functional cerebral development and the simultaneous-successive matrix formulations is offered. This is the important integral role of the understanding of strategies (alternatives) and tactics (methods) and their application to operate on "concrete-active" and "verbal-logical" tasks as Luria calls them. A system of heuristics in the humanistic "brains and machines" comparison is seen as the central mechanisms in understanding children with specific reading disability.

So much for the retrospect. What about the prospect? It is a cliche to say that more research is needed. This does not refer so much to generalized research per se; but to research of the right kind, the right calibre in conception and methodology and focusing on the right topics. To this end, Critchley (1968), the doyen of developmental dyslexia, listed some 17 different areas worthy of further exploration. From his and from other sources as well as from personal experience the present writer would suggest these major areas as worthy of continued attention: early and efficient diagnosis of at-risk children including study of developmental history, speech and language development; detailed case studies of disabled readers including careful follow-ups; studies of theory-based programmes and methods of teaching individual disabled readers; investigation of the nature of functional cerebral development in young and old dyslexics and above all a clear understanding of the nature of the strategies and tactics that children use in processing information. This last-named area of information-processing can be expanded along the lines illustrated in Figure 4-1 to include processing of linguistic segments at the input stage; central elaboration (as in cross-modal transfer and hemispheric reciprocal relationships) and output patterning.

The list of topics is suggestive and by no means exhaustive; it can never be. The general discussions in Chapter 10 touch on some of the topics. There are still lacunae or windows through which one can survey the field and not be a monarch of all one surveys. The masterful exposition of Teuber (1967) on research needs into brain mechanisms and language is but one example of the work still to be done (see also

Darley, Masland in the same Symposium). There are others closer to the homeground of reading dysfunction. As Bacon reminds us that "reading maketh a full man"; so we are enjoined by the Book of Common Prayer to "read, mark, learn, and inwardly digest." This pious note may yet bring us some more hope in experimental and clinical investigation of such a perennial and complex problem as specific reading disability.

LIST OF REFERENCES

Allen, Gary G. Right to Read: Rhetoric or Reality? Phi Delta Kappan, 1971, 53, 4, 217-220.

Altus, G.T. A WISC Profile for Retarded Readers. J. Consult. Psychol., 1956, 20, 155-156.

Anastasi, A. Psychological Testing. New York: Macmillan, 1959.

Annett, M. A Model of the Inheritance of Handedness and Cerebral Dominance, Nature, 1964, 204, 4953, 59-60.

Annett, M. The Binomial Distribution of Right, Mixed and Left Handedness, Quart. J. Exp. Psychol., 1967, 19, 327-333.

Annett, Marian. Handedness, Cerebral Dominance and the Growth of Intelligence. In Bakker, Dirk J. and Satz, Paul (Eds.), Specific Reading Disability: Advances in Theory and Method. Rotterdam: Rotterdam University Press, 1970, 61-79.

Annett, M. The Distribution of Manual Asymmetry. Brit. J. Psychol., 1972, 63, Pt. 3, 343-358.

Annett, Marian and Turner, Ann. Laterality and the Growth of Intellectual Abilities. British Journal of Educational Psychology, 1974, 44, pt. 1, 37-46.

Applebee, Arthur N. Research in Reading Retardation: two Critical Problems. J. Child Psychol. Psychiat., 1971, 12, 91-113.

Armstrong, J. Scott and Soelberg, Peer. On the Interpretation of Factor Analysis. Psychological Bulletin, 1968, 70, 5, 361-364.

Arnheim, Rudolf. Visual Thinking. Berkeley, Los Angeles: University of California Press, 1972.

Attneave, F. Applications of Information Theory to Psychology. New York: Holt, Rinehart and Winston, 1959.

Baddeley, A.D. Semantic and Acoustic Similarity in Short-Term Memory. Nature, 1964, 204, 1116-1117.

Baddeley, A.D. Short-Term Memory for Word Sequences as a Function of Acoustic, Semantic and Formal Similarity. Quarterly Journal of Experimental Psychology, 1966, 18, 362-365.

Bakker, D.J. Temporal Order, Meaningfulness, and Reading Ability. Perceptual Motor Skills, 1967, 24, 1027-1030. (a)

Bakker, Dirk J. Left-Right Differences in Auditory Perception of Verbal and Non-Verbal Material by Children, Quarterly J. Exp. Psychol., 1967, 19, 334-336. (b)

Bakker, Dirk J. Ear Asymmetry with Monaural Stimulation: Task Influences. Cortex, 1969, 5, 36-42.

Bakker, D.J. Temporal Order Perception and Reading Retardation. In Bakker, Dirk J. and Satz, Paul (Eds.) Specific Reading Disability: Advances in Theory and Method. Rotterdam: Rotterdam University Press, 1970, pp. 81-96.

Bakker, Dirk J. Temporal Order in Disturbed Reading: Developmental and Neuropsychological Aspects in Normal and Reading-Retarded Children. Rotterdam: Rotterdam University Press, 1972.

Bakker, Dirk J. Hemispheric Specialization and Stages in the Learning-to-Read Process. Orton Society Bulletin, 1973, 23, 15-27.

Bakker, Dirk J. and Satz, Paul (Eds.) Specific Reading Disability: Advances in Theory and Method. Rotterdam: Rotterdam University Press, 1970.

Bartlett, F. Thinking: An Experimental and Social Study. New York: Basic Books, 1958.

Bartz, W.H., Satz, P., and Fennell, Eileen. Grouping Strategies in Dichotic Listening: the Effects of Instructions, Rate, and Ear Asymmetry. Journal of Experimental Psychology, 1967, 74, 1, 132-136.

Bartz, W.H., Satz, P., Fennell, E., and Lally, J.R. Meaningfulness and Laterality in Dichotic Listening. Journal of Experimental Psychology, 1967, 73, 204-210.

Baumeister, Alfred A. Problems in Comparative Studies of Mental Retardates and Normals. American J. Mental Deficiency, 1967, 71, 869-875.

Beery, Judith W. Matching of Auditory and Visual Stimuli by Average and Retarded Readers. Child Development, 1967, 38, 3, 827-834.

Belmont, L. and Birch, H.G. Lateral Dominance, Lateral Awareness, and Reading Disability. Child Development, 1965, 36, 59-71.

Belmont, L. and Birch, H.G. The Intellectual Profile of Retarded Readers. Perceptual Motor Skills, 1966, 22, 787-816.

Bender, Lauretta. The Visual Motor Gestalt Test and its Clinical Use. Research Monograph No. 3. New York: Amer. Orthopsychiatric Ass'n., 1938.

Bender, Lauretta. Problems in Conceptualization and Communication in Children with Developmental Alexia. In Hoch, P.H. and Zubin, J. (Eds.) Psychopathology of Communication. New York: Grune and Stratton, 1958, 155-176.

Benton, A.L. The Revised Visual Retention Test: Clinical and Experimental Applications. New York: Psychological Corp., 1955.

Benton, A.L. The Fiction of the "Gerstmann Syndrome." J. Neurol. Neurosurg. Psychiat., 1961, 24, 176-181.

Benton, Arthur L. Dyslexia in relation to Form Perception and Directional Sense. In Money, John (Ed.) Reading Disability: Progress and Research Needs in Dyslexia. Baltimore: Johns Hopkins, 1962.

Benton, Arthur L. The Problem of Cerebral Dominance. The Canadian Psychologist, 1965, 6a, 4, 332-348.

Benton, Arthur L. Minimal Brain Dysfunction from a Neuropsychological Point of View. Annals of the New York Academy of Sciences, 1973, 205, 29-37.

Berlin, Charles I., Lowe-Bell, Sena S., Cullen, J.K., Jr., Thompson, C.L., and Loovis, C.F. Dichotic Speech Perception: an Interpretation of Right-Ear Advantage and Temporal Offset Effects. The Journal of the Acoustical Society of America, 1973, 53, 3, 699-709.

Bernstein, B. Social Structure, Language and Learning. Educational Research, 1961, 3, 163-176.

Bernstein, B. Social Class Speech Systems and Psychotherapy. In Riessman, F., Cohen, J. and Pearl, A. (Eds.) Mental Health of the Poor. New York: Free Press of Glencoe, Inc., 1964.

Bernstein, B. and Young, D. Some Aspects of the Relationship between Communication and Performances in Tests. In Meade, J.E. and Parkes, A.S. (Eds.) Genetic and Environmental Factors in Human Ability. Edinburgh: Oliver and Boyd, 1966, pp. 15-23.

Bever, T.G. The Nature of Cerebral Dominance in Speech Behaviour of the Child and Adult. In Huxley, Renira and Ingram, Elisabeth (Eds.) Language Acquisition: Models and Methods. London: Academic Press, 1971, pp. 231-261.

Binet, A. and Simon, T. The Development of Intelligence in the Child. In Binet, A. and Simon, T. The Development of Intelligence in Children. Trans. Kite, E.S., Baltimore: Williams and Wilkins, 1916. Originally published as Le développement de l'intelligence chez les enfants. L'Année Psychologique, 1908, 14, 1-94.

Birch, Herbert G. Dyslexia and the Maturation of Visual Function. In Money, John (Ed.) Reading Disability: Progress and Research Needs in Dyslexia. Baltimore: Johns Hopkins, 1962, pp. 161-169.

Birch, Herbert G. (Ed.) Brain Damage in Children: the Biological and Social Aspects. Baltimore, Maryland: Williams and Wilkins, 1964.

Birch. H.G. and Belmont, L. Auditory-Visual Integration in Normal and Retarded Readers. Amer. J. Orthopsychiatry, 1964, 34, 852-861.

Birch, H.G. and Belmont, L. Auditory-Visual Integration, Intelligence, and Reading Ability in School Children. Percept. Motor Skills, 1965, 20, 295-305.

Birch, H.G. and Bitterman, M.E. Sensory Integration and Cognitive Theory. Psychol. Review, 1951, 58, 355-361.

Birch, H.G. and Lefford, A. Intersensory Development in Children. Monographs of the Society for Research in Child Development, 1963, 28 (5, Whole No. 89).

Blank, M., Altman, D.L., and Bridger, W.H. Cross-modal Transfer of Form Discrimination in Preschool Children. Psychonomic Science, 1968, 10, 51-52.

Blank, M. and Bridger, W.H. Deficiencies in Verbal Labelling in Retarded Readers. Amer. J. Orthopsychiatry, 1966, 36, 840-847.

Blank, M., Weider, S., and Bridger, W.H. Verbal Deficiencies in Abstract Thinking in Early Reading Retardation. Amer. J. Orthopsychiatry, 1968, 38, 823-834.

Bloom, B.S. Stability and Change in Human Characteristics, New York: Wiley, 1964.

Bloomfield, L. Linguistics and Reading. Elementary English Review, 1942, 19, 125-130.

Bloomfield, Leonard. Linguistics and Reading. Language Learning, 1955, 5, 94-107.

Bocca, E., Calearo, C., Cassinari, V., and Migliavacca, F. Testing 'Cortical' Hearing in Temporal Lobe Tumors. Acta Oto-Laryngol, 1955, 45, 289-304.

Boder, Elena. Developmental Dyslexia: Prevailing Diagnostic Concepts and a New Diagnostic Approach. In Myklebust, H.R. (Ed.) Progress in Learning Disabilities: Volume II. New York: Grune and Stratton, 1971, pp. 293-321.

Boller, F. and De Renzi, E. Relationship between Visual Memory Defects and Hemispheric Locus of Lesion. Neurology, 1967, 17, 1052-1058.

Bracht, Glenn H. and Glass, Gene V. The External Validity of Experiments. American Educational Research Journal, 1968, 5, 4, 437-474.

Branch, C., Milner, B., and Rasmussen, T. Intercarotid Sodium Amytal for the Lateralization of Cerebral Speech Dominance. J. Neurosurgery, 1964, 21, 399-405.

Brenner, M.W. and Gillman, S. Visuomotor Ability in School Children--a Survey. Developmental Medicine and Child Neurology, 1966, 8, 686-703.

Broadbent, D.E. The Role of Auditory Localization in Attention and Memory Span. J. Exp. Psychol., 1954, 47, 3, 191-196.

Broadbent, D.E. Successive Responses to Simultaneous Stimuli. Quart. J. Exp. Psychol., 1956, 8, 145-152.

Broadbent, D.E. Perception and Communication. London: Pergamon, 1958.

Broadbent, D.E. Information Processing in the Nervous System. Science, 1965, 150, 457-462.

Broadbent, D.E. Decision and Stress. New York: Academic Press, 1971.

Broadbent, D.E. and Gregory, M. Stimulus Set and Response Set: the Alternation of Attention. Quart. J. Exp. Psychol., 1964, 16, 309-318.

Brown, Roger. Words and Things. Glencoe, Ill.: The Free Press, 1958.

Bruner, J.S., Goodnow, J.J., and Ausin, G.A. A Study of Thinking. New York: Wiley, 1956.

Bryant, N. Dale and Kass, Corrine E. (Eds.) Leadership Training Institute in Learning Disabilities. Final Report, U.S. Office of Education Project No. 127145. Washington, D.C.: U.S. Office of Education, 1972.

Bryant, P.E. Comments on the Design of Developmental Studies of Cross-Modal Matching and Cross-Modal Transfer. Cortex, 1968, 4, 127-137.

Bryden, M.P. Order of Report on Dichotic Listening. Canad. J. Psychol., 1962, 16, 291-299.

Bryden, M.P. Short-term Memory for Unbalanced Dichotic Lists. Psychon. Science, 1966, 6, 8, 379-380.

Bryden, M.P. A Model for the Sequential Organization of Behaviour. Canad. J. Psychol., 1967, 21, 1, 37-56. (a).

Bryden, M.P. An Evaluation of Some Models of Laterality Effects in Dichotic Listening. Acta oto-laryngologica, 1967, 63, 595-604. (b).

Bryden, M.P. Laterality Effects in Dichotic Listening: Relations with Handedness and Reading Ability in Children. Neuropsychologia, 1970, 40, 443-450.

Bryden, M.P. Auditory-Visual and Sequential-Spatial Matching in Relation to Reading Ability. Child Development, 1972, 43, 3, 824-832.

Bryden, M.P. and Allard, F. Developmental Aspects of Dichotic Listening Laterality. Paper read at the thirty-fourth Canadian Psychological Association Annual Conference, June 1973, Victoria, Canada.

Burke, H.R. Raven's Progressive Matrices: a Review and Critical Evaluation. J. Genetic Psych., 1958, 93, 199-228.

Burt, C. Experimental Tests of Higher Mental Processes. J. Exp. Ped., 1911, 1, 93-112.

Burt, C. Mental and Scholastic Tests. London: P.S. King & Son. (7th Impression, 1949, Staple Press), 1921.

Burt, Cyril. The Young Delinquent. London: University of London Press, 1925.

Burt, Cyril. The Backward Child. London: University of London Press, 1937 (Revised 1961).

Burt, Cyril. The Accomplishment Quotient: a Reply. British Journal of Educational Psychology, 1959, 29, 259-260.

Burt, Cyril. The Genetic Determination of Differences in Intelligence: A Study of Monozygotic Twins Reared Together and Apart. Brit. J. Psychol., 1966, 57, 137-153.

Burt, C. Capacity and Achievement. Education, August, 1967, 198-201.

Burt, Cyril. Inheritance of General Intelligence. American Psychologist, 1972, 27, 3, 175-190.

Burt, Cyril and Howard, M. The Multifactorial Theory of Inheritance and its Application to Intelligence. Brit. J. Stat. Psychol., 1956, 9, 95-131.

Burt, Cyril and Howard, M. The Relative Influence of Heredity and Environment on Assessments of Intelligence. Brit. J. Stat. Psychol., 1957, 10, 99-104.

Butters, N. and Brody, Betty Ann. The Role of the Left Parietal Lobe in the Mediation of Intra- and Cross-Modal Associations. Cortex, 1968, 4, 4, 328-343.

Calfee, Robert C., Lindamood, Patricia, P., and Lindamood, C. Acoustic-Phonetic Skills and Reading--Kindergarten through Twelfth Grade. J. Ed. Psychol., 1973, 64, 3, 293-298.

Carr, B.M. A New System for preparing Dichotic Listening Tapes. Paper presented at Annual Convention of Amer. Speech and Hearing Ass'n., Chicago, 1969.

Carroll, John B. The Nature of the Reading Process. In Singer, H. and Ruddell, Robert B. (Eds.) Theoretical Models and Processes of Reading. Newark, Delaware: International Reading Ass'n., 1970.

Cattell, R.B. The Scree Test for the Number of Factors. Multivariate Behavioural Research, 1966, 1, 245-276.

Cernacek, J. Handedness as a Quantitative Estimate. J. Neurol. Science, 1964, 1, 152-159.

Chalfant, James C. and Scheffelin, Margaret A. (Eds.) Central Processing Dysfunction in Children: a Review of Research. Bethesda, Md.: National Institute of Neurological Diseases and Stroke (NINDS) Monog. No. 9, 1969.

Chall, Jeanne S. Learning to Read: the Great Debate. New York: McGraw-Hill, 1967.

Chase, Richard Allen. Biological Dimensions of Language and Language Disorders in Children. Address delivered at the 19th Annual Meeting of the Orton Society, October, 1968, New York. The Orton Society Reprint No. 23.

Cherry, E.C. Some Experiments on the Recognition of Speech, with One and Two Ears. J. Acoust. Soc. Amer., 1953, 25, 975-979.

Cherry, E.C. and Taylor, W.K. Some Further Experiments upon the Recognition of Speech, with One and Two Ears. J. Acoust. Soc. Amer., 1954, 26, 554-559.

Chomsky, Noam. Some General Properties of Phonological Rules. Language, 1967, 43, 102-128.

Chomsky, Noam. Phonology and Reading. In Levin, Harry and Williams, Joanna P. (Eds.) Basic Studies on Reading. New York: Basic Books, 1970, pp. 3-18.

Clements, Sam D. Minimal Brain Dysfunction in Children: Terminology and Identification. National Institute on Neurological Diseases and Blindness (NINDB) Monograph No. 3 (Public Health Service Publication No. 1415). Washington, D.C.: U.S. Gov't. Printing Office, 1966.

Clements, Sam D. (Ed.) Minimal Brain Dysfunction in Children: Educational, Medical and Health Related Services. U.S. Dept. of Health, Education, and Welfare (Public Health Service Publication No. 2015). Washington, D.C.: U.S. Gov't. Printing Office, 1969.

Connors, C.K., Kramer, K., Guerra, F. Auditory Synthesis and Dichotic Listening in Children with Learning Disabilities. J. Special Education, 1969, 3, 2, 163-170.

Conrad, R. The Role of the Nature of the Material in Verbal Learning. Acta Psychologica, 1965, 24, 244-252.

Cooley, W.W. and Lohnes, P.R. Multivariate Procedures for the Behavioural Sciences. New York: Wiley, 1962.

Cooper, F.S. How is Language Conveyed by Speech? In Kavanagh, J.F. and Mattingly, I.G. (Eds.) Language by Ear and by Eye: the Relationships between Speech and Reading. Cambridge, Mass.: M.I.T. Press, 1972, 25-45.

Cooper. A., Achenbach, K., Satz, P., and Levy, C. Order of Report and Ear Asymmetry in Dichotic Listening. Psychon. Science, 1967, 9, 97-98.

Corballis, Michael C., and Beale, Ivan L. On Telling Left from Right. Scientific American, 1971, 224, 3, 96-104.

Crane, A.R. An Historical and Critical Account of the Accomplishment Quotient Idea. British Journal of Educational Psychology, 1959, 29, 252-259.

Critchley, M. The Parietal Lobes. Baltimore: Williams and Wilkins, 1953.

Critchley, M. Peyne Memorial Lecture: Inborn Reading Disorders of Central Origin. Trans. Oph. Society, 1961, 81, 459-480.

Critchley, M. Speech and Speech Loss in Relation to Duality of the Brain. In Mountcastle, V.B. (Ed.). Interhemispheric Relations and Cerebral Dominance. Baltimore: The Johns Hopkins Press, 1962, pp. 208-213.

Critchley, M. Developmental Dyslexia. London: Heinemann, 1964.

Critchley, M. Topics worthy of Research. In Keeney, A.H. and Keeney, Virginia T. (Eds.) Dyslexia: Diagnosis and Treatment of Reading Disorder. St. Louis: C.V. Mosby, 1968, pp. 165-173.

Critchley, M. The Dyslexic Child. London: Heinemann, 1970.

Cromer, Ward. The Difference Model: a New Explanation for Some Reading Difficulties. J. Ed. Psychol., 1970, 61, 6, 471-483.

Cronbach, Lee J. The Two Disciplines of Scientific Psychology. Amer. Psychologist, 1957, 12, 671-684.

Curry, F.K.W. A Comparison of Left-Handed and Right-Handed Subjects on Verbal and Non-Verbal Dichotic Listening Tasks. Cortex, 1967, 3, 343-352.

Curry, F.K.W. and Gregory, H. The Performance of Stutterers on Dichotic Listening Tasks thought to Reflect Cerebral Dominance. J. Speech Hearing Res., 1969, 12, 73-82.

Curry, F.K.W., and Rutherford, D. Recognition and Recall of Dichotically presented Verbal Stimuli by Right and Left-Handed Persons. Neuropsychologia, 1967, 5, 119-126.

Darley, F.L. Lacunae and Research Approaches to Them. IV. In Millikan, Clark H. and Darley, F.L. (Eds.) Brain Mechanisms Underlying Speech and Language. New York: Grune and Stratton, 1967, 236-240.

Das, J.P. Patterns of Cognitive Ability in Nonretarded and Retarded Children. Amer. J. Ment. Deficiency, 1972, 77, 1, 6-12. (a).

Das, J.P. A Report on Indian Education. B) Memory and Reasoning in Native Children: an Effort at Improvement through the Teaching of Cognitive Strategies. Edmonton: University of Alberta Press, 1972. (b).

Das, J.P. Structure of Cognitive Abilities: Evidence for Simultaneous and Successive Processing. J. Ed. Psychol., 1973, 65, 1, 103-108. (a).

Das, J.P. Cultural Deprivation and Cognitive Competence. In Ellis, N.R. (Ed.) International Review of Research in Mental Retardation, Vol. 6, New York: Academic Press, 1973, pp. 1-53. (b).

Das, J.P. The Uses of Attention: Alberta Journal of Educational Research, 1973, 19, 2, 99-108. (c).

Davis, Frederick B. (Ed.) The Literature of Research in Reading with Emphasis on Models: Final Report. New Brunswick, N.J.: Rutgers-the State University, 1971.

de Hirsch, K., Jansky, J.J. and Langford, W.S. Predicting Reading Failure: a Preliminary Study of Reading, Writing and Spelling Disabilities in Preschool Children. London: Harper and Row, 1966.

Dee, H.L. Auditory Asymmetry and Strength of Manual Preference. Cortex, 1971, 7, 236-245.

Denny, M. Ray. Research in Learning and Performance. In Stevens, H.A., and Heber, R. (Eds.) Mental Retardation: a Review of Research. Chicago: University of Chicago Press, 1964, 100-142.

Department of Education and Science. Children with Specific Reading Difficulties. Report of the Advisory Committee on Handicapped Children. London: Her Majesty's Stationery Office, 1972.

Deutsch, Cynthia P. Language in the Disadvantaged. In Deutsch, M. (Ed.) The Disadvantaged Child: Selected Papers of Martin Deutsch and Associates. New York and London: Basic Books, 1967.

Diack, Hunter. The Teaching of Reading in Spite of the Alphabet. New York: Philosophic Library, 1965.

Dingman, H.F. and Tarjan, G. Mental Retardation and the Normal Distribution Curve. Amer. J. Mental Deficiency, 1960, 64, 991-994.

Dobie, R.A. and Simmons, F.B. A Dichotic Threshold Test: Normal and Brain-Damaged Subjects. J. Speech Hearing Res., 1971, 14, 1, 71-81.

Dockrell, W.B. The Use of the Wechsler Intelligence Scale for Children in the Diagnosis of Retarded Readers. Alberta J. Ed. Research, 1960, 6, 2, 86-91.

Doehring, D.G. Patterns of Impairment in Specific Reading Disability. Bloomington: Indiana University Press, 1968.

Doehring, D.G. and Rabinovitch, S. Auditory Abilities of Children with Learning Problems, J. Learning Disabilities, 1969, 2, 9, 467-475.

Douglas, J.W.B. The Home and the School. London: MacGibbon, 1964.

Downing, John and Thackray, D.R. Reading Readiness. London: University of London Press, 1971.

Dukes, William. N = 1. Psychological Bulletin, 1965, 64, 1, 74-79.

Dunn, Lloyd M. Minimal Brain Dysfunction: a Dilemma for Educators. In Frierson, Edward C. and Barbe, Walter B. (Eds.) Educating Children with Learning Disabilities. New York: Appleton-Century-Crofts, 1967, pp. 117-132.

Dykman, Roscoe A., Ackerman, Peggy T., Clements, Sam D., and Peters, John E. Specific Learning Disabilities: an Attentional Deficit Syndrome. In Myklebust, Helmer, R. (Ed.) Progress in Learning Disabilities: Volume II. New York: Grune and Stratton, 1971, pp. 56-93.

Dziuban, C.D. and Harris, C.W. On the Extraction of Components and the Applicability of the Factor Model. American Educational Research Journal, 1973, 10, 93-99.

Efron, Robert. The Effect of Handedness on the Perception of Simultaneity and Temporal Order. Brain, 1963, 86, 261-284. (a).

Efron, R. The Effect of Stimulus Intensity on the Perception of Simultaneity in Right- and Left-Handed Cases. Brain, 1963, 86, 285-294. (b).

Efron, R. Temporal Perception, Aphasia, and Déjà Vu. Brain, 1963, 86, 403-424. (c).

Efron, R. Discussion of Paper by Hirsh, Ira J. In Millikan, C.H. and Darley, F.L. (Eds.) Brain Mechanisms underlying Speech and Language. New York: Grune and Stratton, 1967, pp. 30 et. seq.

Eisenberg, Leon. Introduction. In Money, John (Ed.) Reading Disability: Progress and Research Needs in Dyslexia. Baltimore: Johns Hopkins, 1962.

Eisenberg, Leon. Reading Retardation: I. Psychiatric and Sociologic Aspects. Pediatrics, 1966, 37, 352-365.

Eisenson, Jon. Developmental Aphasia: a Speculative View with Therapeutic Implications. J. Speech and Hearing Disorders, 1968, 33, 1, 3-13.

Elkonin, D.B. The Psychology of Mastering the Elements of Reading. In Simon, B., and Simon, Joan (Eds.) Educational Psychology in the U.S.S.R. Stanford: Stanford University Press, 1963, pp. 165-179.

Elkonin, D.B. U.S.S.R. In Downing, J. (Ed.) Comparative Reading: Cross-National Studies of Behavior and Processes in Reading and Writing. New York: Macmillan, 1973, pp. 551-579.

Ettinger, G. Analysis of Cross-Modal Effects and their Relationship to Language. In Millikan, Clark H. and Darley, F.L. (Eds.) Brain Mechanisms underlying Speech and Language. New York: Grune and Stratton, 1967, 53-60.

Farnham-Diggory, Sylvia. Self, Future, and Time: a Developmental Study of the Concepts of Psychotic, Brain-Damaged, and Normal Children. Monographs of the Society for Research in Child Development. Serial No. 103, 1966, 31, 1.

Farnham-Diggory, Sylvia. Symbol and Synthesis in Experimental 'Reading'. Child Development, 1967, 38, 221-231.

Farnham-Diggory, Sylvia. Cognitive Synthesis in Negro and White Children. Monographs of the Society for Research in Child Development, 1970, 35 (2, Whole No. 135).

Farnham-Diggory, Sylvia (Ed.) Information Processing in Children. New York: Academic Press, 1972.

Fay, Warren H. Temporal Sequence in the Perception of Speech. the Hague: Mouton, 1966.

Foulds, G.A. Variation in the Intellectual Abilities of Adults. Amer. J. of Psychol., 1949, 62, 238-246.

Fraisse, P. The Psychology of Time. London: Eyre and Spottiswoode, 1964 (translated by Leith, Jennifer).

Fries, Charles C. Linguistics and Reading. New York: Holt, Rinehart and Winston, 1962.

Fujimura, O. and Kagaya, R. Structural Patterns of Chinese Characters. Paper read at the International Conference on Computational Linguistics, Sanga-Saby, Sweden, September 1-4, 1969.

Gardner, R.A. and Gardner, Beatrice. Teaching Sign Language to a Chimpanzee. Science, 1969, 165, 664-672.

Gates, A.I. The Psychology of Reading with Special Reference to Disability. New York: Teachers College, Columbia University. Teachers College Contribution to Education, No. 129, 1922.

Gazzaniga, M.S., Bogan, J.E., and Sperry, R.W. Observations on Visual Perception after Disconnection of the Cerebral Hemispheres in Man. Brain, 1965, 88, 221-236.

Geschwind, N. The Anatomy of Acquired Disorders of Reading. In Money, John (Ed.) Reading Disability: Progress and Research Needs in Dyslexia. Baltimore: Johns Hopkins, 1962.

Geschwind, Norman. The Development of the Brain and the Evolution of Language. Monograph Series on Languages and Linguistics. Georgetown: Georgetown University Press, 1964, 17, 155-169.

Geschwind, Norman. Disconnexion Syndrome in Animals and Man. Brain, 1965, 88, 237-294, 585-644.

Geschwind, Norman. Neurological Foundations of Language. In Myklebust, Helmer, R. (Ed.) Progress in Learning Disabilities. Volume I. New York and London: Grune and Stratton, 1968, pp. 182-198.

Geschwind, Norman. The Organization of Language and the Brain. Science, 1970, 170, 3961, 940-944.

Geschwind, Norman. Anatomical Evolution and the Human Brain. The Orton Society Bulletin, 1972, 22, 7-13.

Geschwind, Norman and Levitsky, Walter. Human Brain: Left-Right Asymmetries in Temporal Speech Region. Science, July 1968, 161, 3837, 186-187.

Gesell, A. The Embryology of Behaviour. New York: Harper and Row, 1945.

Gibson, Eleanor J. Experimental Psychology of Learning to Read. In Money, J. (Ed.) The Disabled Readers: Education of the Dyslexic Child. Baltimore: The Johns Hopkins Press, 1966, pp. 41-58.

Gibson, Eleanor J. Principles of Perceptual Learning and Development. New York: Appleton-Century-Crofts, 1969.

Gibson, Eleanor J. Learning to Read. In Singer, Harry and Ruddell, Robert B. (Eds.) Theoretical Models and Processes of Reading. Newark, Delaware: International Reading Ass'n., 1970. (a).

Gibson, Eleanor J. Ontogeny of Reading. American Psychologist, 1970, 25, 2, 136-143. (b).

Gibson, Eleanor J. Reading for some Purpose: Keynote Address. In Kavanagh, J.F. and Mattingly, I.G. (Eds.) Language by Ear and by Eye: the Relationships between Speech and Reading. Cambridge, Mass.: the M.I.T. Press, 1972.

Gibson, E.J., Osser, H., and Pick, A.D. A Study in the Development of Grapheme-Phoneme Correspondences. J. Verb. Learn. Verb. Behav., 1963, 2, 142-146.

Gibson, E.J., Pick, A., Osser, H., and Hammond, M. The Role of Grapheme-Phoneme Correspondence in the Perception of Words. Amer. J. Psychol., 1962, 75, 554-570.

Gibson, Eleanor J., Shurcliff, A., & Yonas, A. Utilization of Spelling Patterns of Deaf and Hearing Subjects. In Levin, Harry and Williams, Joanna P. (Eds.) Basic Studies on Reading. New York: Basic Books, 1970, pp. 57-73.

Goldberg, H. The Ophthalmologist Looks at the Reading Problem. Amer. J. Ophthalmology, 1959, 47, 67.

Goodglass, H. Binaural Digit Presentation and Early Lateralized Brain Damaged. Cortex, 1967, 3, 295-306.

Goodglass, H. Developmental Comparison of Vowels and Consonants in Dichotic Listening. Journal of Speech and Hearing Research, 1973, 16, 4, 744-752.

Goodglass, H. and Quadfasel, F.A. Language Laterality in Left-Handed Aphasics. Brain, 1954, 77, 521-548.

Goodman, Kenneth S. (Ed.) The Psycholinguistic Nature of the Reading Process. Detroit: Wayne State University Press, 1968.

Goodman, K.S. Words and Morphemes in Reading. In Goodman, K.S. and Fleming, J.T. (Eds.) Psycholinguistics and the Teaching of Reading. Newark, Delaware: International Reading Ass'n., 1969, 25-33.

Goodnow, Jacqueline J. Eye and Hand: Differential Sampling of Form and Orientation Properties. Neuropsychologia, 1969, 7, 365-373.

Goodnow, Jacqueline J. Matching Auditory and Visual Series: Modality Problem or Translation Problem? Child Development, 1971, 42, 1187-1201. (a).

Goodnow, Jacqueline J. The Role of Modalities in Perceptual and Cognitive Development. In Hill, J.P. (Ed .) Minnesota Symposia on Child Psychology, Vol. 5, Minn.: University of Minnesota Press, 1971. (b).

Goodnow, Jacqueline J. Rules and Repertoires, Rituals and Tricks of the Trade: Social and Informational Aspects to Cognitive and Representational Development. In Farnham-Diggory, Sylvia (Ed.) Information Processing in Children. New York: Academic Press, 1972, 83-102.

Graham, F.K. and Kendall, B.S. Performance of Brain-Damaged Cases on a Memory-for-Designs Test, J. Abn. Soc. Psychol., 1946, 41, 303-314.

Graham, F.K. and Kendall, B.S. Memory-for-Designs Test: Revised General Manual. Percept. Motor Skills, 1960, 11, 147-188. (Monogr. Suppl. No. 2-VII).

Gray, J.A. and Wedderburn, A.A.I. Grouping Strategies with Simultaneous Stimuli. Quarterly Journal of Experimental Psychology, 1960, 12, Pt. 1, 180-184.

Guilford, J.P. When not to Factor Analyze. Psychological Bulletin, 1952, 49, 1, 26-37.

Guttman, L. Image Theory for the Structure of Quantitative Variates. Psychometrika, 1953, 18, 277-296.

Haber, Ralph Norman. Perception and Thought: an Information-Processing Analysis. In Voss, James F. (Ed.) Approaches to Thought. Columbus, Ohio: Charles E. Merrill, 1969, 1-26.

Hall, J.L. and Goldstein, M.H. Representation of Binaural Stimuli by Single Units in Primary Auditory Cortex of Unanaesthetized Cats. J. Acoust. Soc. Amer., 1968, 43, 456-461.

Halle, M., Some Thoughts on Spelling. In Goodman, K.S. and Fleming, J.T. (Eds.) Psycholinguistics and the Teaching of Reading. Newark, Delaware: International Reading Ass'n., 1969.

Hallgren, Bertil. Specific Dyslexia (Congenital Word Blindness): a Clinical and Genetic Study. Acta Psychiatrica et Neurologia Supp. 65. Stockholm, 1950.

Harris, A.J. Diagnosis and Remedial Instruction in Reading. In Robinson, Helen M. (Ed.) Innovation and Change in Reading Instruction. The Sixty-Seventh Yearbook of NSSE, Pt. II, Chicago: Chicago University Press, 1968, pp. 159-194.

Harris, C.W. Some Recent Developments in Factor Analysis. Educational and Psychological Measurement, 1964, 24, 193-205.

Harris, D.B. Children's Drawings as Measures of Intellectual Maturity. New York: Harcourt, Brace, 1963.

Haywood, H.C. Mental Retardation as an Extension of the Developmental Laboratory. Amer. J. Mental Deficiency, 1970, 75, 5-9.

Hebb, D.O. The Organization of Behaviour. New York: Wiley, 1949.

Hebb, D.O. Lambert, W.E., and Tucker, G.R. Language, Thought and Experience. The Modern Language Journal, 1971, 55, 4, 212-222.

Hecaen, H. and Ajuriaguerra, Julian de. Left Handedness: Manual Superiority and Cerebral Dominance. New York: Grune and Stratton, 1964.

Hecaen, H. and Piercy, M. Paroxysmal Dysphasia and the Problem of Cerebral Dominance. J. Neurol. Neurosurg. Psychiat., 1956, 19, 194-201.

Hermann, Knud. Reading Disability: A Medical Study of Word-Blindness and Related Handicaps. Springfield, Ill.: Charles C. Thomas, 1959.

Hirsh, I.J. Auditory Perception of Temporal Order. J. Acoust. Soc. Amer., 1959, 31, 759-767.

Hirsh, I.J. Information Processing in Input Channels for Speech and Language: the Significance of Serial Order of Stimuli. In Millikan, C.H. and Darley, F.L. (Eds.) Brain Mechanisms underlying Speech and Language. New York: Grune and Stratton, 1967, 21-27.

Hirsh, I.J. and Fraisse, P. Simultanéité et Succession de Stimuli Hétérogènes. Année Psychologique, 1964, 64, 1-19.

Hirsh, I.J. and Sherrick, E.E. Perceived Order in Different Sense Modalities. J. Exp. Psychol., 1961, 62, 423-432.

Hirst, L.S. The Usefulness of a Two-Way Analysis of WISC Subtests in the Diagnosis of Remedial Reading Problems. J. Exp. Ed., 1960, 29, 2, 153-160.

Holloway, Ruth. Right to Read: New Director, New Approach. Phi Delta Kappan, 1971, 53, 4, 221-224.

Hopkins, Kenneth D. Regression and the Matching Fallacy in Quasi-Experimental Research. J. Special Education, 1969, 3, 4, 329-336.

Huey, E.B. The Psychology and Pedagogy of Reading. New York: Macmillan, 1908. Paperback Reprint, Cambridge, Mass.: M.I.T. Press, 1968.

Hull, C.L. Principles of Behavior. New York: Appleton-Century-Crofts, 1943.

Hunt, J. McV. Intelligence and Experience. New York: Ronald Press, 1961.

Hunt, J. McV. The Challenge of Incompetence and Poverty: Papers on the Role of Early Education. Ill: University of Illinois Press, 1969.

Hunt, J. McV. Heredity, Environment and Class or Ethic Differences. In Assessment in a Pluralistic Society. Proceedings of the 1972 Invitational Conference on Testing Problems. Princeton, New Jersey: Educational Testing Service, 1973, pp. 3-36.

Huntley, R.M.C. Heritability of Intelligence. In Meade, J.E. and Parkes, A.S. (Eds.) Genetic and Environmental Factors in Human Abilities. New York: Plenum Press, 1966, pp. 201-218.

Ilg, Frances L. and Ames, Louis Bates. School Readiness: Behavior Tests used at the Gesell Institute. New York: Harper and Row, 1964.

Inglis, James. Dichotic Listening and Cerebral Dominance. Acta-oto-laryng., 1965, 60, 231-238.

Inglis, J. and Caird, W.K. Age Differences in Successive Responses to Simultaneous Stimulation. Canad. J. Psychol., 1963, 17, 1, 98-105.

Inglis, J. and Sanderson, R.E. Successive Responses to Simultaneous Stimulation in Elderly Patients with Memory Disorder. Journal of Abnormal and Social Psychology, 1961, 62, 709-712.

Inglis, James and Sykes, D.H. Some Sources of Variation in Dichotic Listening Performance in Children. J. Exp. Child Psychology, 1967, 5, 480-488.

Ingram. T.T.S. The Nature of Dyslexia. In Young, F.A. and Lindsley, D.B. (Eds.) Early Experience and Visual Information Processing in Perceptual and Reading Disorders. Washington, D.C.: National Academy of Sciences, 1970, 405-444.

Inhelder, B., and Piaget, J. The Early Growth of Logic in the Child: Classification and Seriation. (translated by Lunzer, A.E. and Papert, D.) London: Routledge and Kegan Paul, 1964.

Irvine, J.W. Handedness Preference, Manual Dexterity, Ear Asymmetry in Dichotic Listening and Grade 2 Reading Proficiency. Unpublished Ph.D. Dissertation, University of Alberta, 1972.

Jakobson, Roman. About the Relation between Visual and Auditory Signs. In Wathan-Dunn, W. (Ed.) Models for the Perception of Speech and Visual Form: Proceedings of a Symposium. Cambridge, Mass.: M.I.T. Press, 1967.

Jakobson, R. Verbal Communication. Scientific American, 1972, 227, 3, 72-80.

Jakobson, R., Fant, C.G.M., and Halle, M. Preliminaries to Speech Analysis. Cambridge, Mass.: M.I.T. Press, 1963.

Jennrich, R.I. An Asymptotic χ^2 Test for the Equality of Two Correlation Matrices. J. Amer. Stat. Ass'n., 1970, 65, 330, 904-912.

Jensen, A.R. Individual Differences in Concept Learning. In Klausmeier, H.J. and Harris, C.W. (Eds.) Analysis of Concept Learning. New York: Academic Press, 1966, 139-154.

Jensen, A.R. How Much Can we Boost IQ and Scholastic Achievement? Harvard Educational Review, Winter, 1969, 39, 1, 1-123.

Jensen, A.R. A Theory of Primary and Secondary Familial Mental Retardation. In Ellis, N.R. (Ed.) International Review of Research in Mental Retardation, Volume 4. New York: Academic Press, 1970, 33-100.

Johnson, Doris and Myklebust, H.R. Learning Disabilities: Educational Principles and Practices. New York: Grune and Stratton, 1967.

Jones, D. and Spreen, O. Dichotic Listening by Retarded Children: the Effects of Ear Order and Abstractness. Child Development, 1967, 38, 1, 101-105.

Joynt, R.J. Paul Pierre Broca: his contribution to the knowledge of Aphasia. Cortex, 1964, 1, 206-213.

Kahneman, D. Attention and Effort. Englewood Cliffs, New Jersey: Prentice-Hall, 1973.

Kaiser, H.F. Image Analysis. In Harris, C.W. (Ed.) Problems in Measuring Change. Madison: University of Wisconsin Press, 1963, 156-166.

Kaiser, H.F. and Caffrey, J. Alpha Factor Analysis. Psychometrika, 1965, 30, 1-14.

Katzin, B.E., Corballis, M.C., and Lockhart, R.S. Attention Strategies in Dichotic Listening. Canadian Journal of Psychology, 1972, 26, 3, 207-218.

Kavanagh, James F. (Ed.) Communication by Language: the Reading Process. Bethseda, Maryland: U.S. Department of Health, Education, and Welfare. National Institute of Child Health and Human Development, 1968.

Kavanagh, J.F. and Mattingly, I.G. (Eds.) Language by Ear and by Eye: the Relationships between Speech and Reading. Cambridge, Mass.: the M.I.T. Press, 1972.

Kendall, B.S. and Graham, F.K. Further Standardization of the Memory-for-Designs Test on Children and Adults. J. Consult. Psychol., 1948, 12, 349-354.

Kimura, D. Some Effects of Temporal-Lobe Damage on Auditory Perception. Canad. J. Psychol., 1961, 15, 156-165. (a).

Kimura, D. Cerebral Dominance and the Perception of Verbal Stimuli. Canad. J. Psychol., 1961, 15, 166-171. (b).

Kimura, D. A Note on Cerebral Dominance in Hearing. Acta oto-laryng., (Stockh.), 1963, 56, 617.

Kimura, D. Left-Right Differences in the Perception of Melodies. Quarterly Journal of Experimental Psychology, 1964, 16, 355-358.

Kimura, D. Dual Functional Asymmetry of the Brain in Visual Perception. Neuropsychologia, 1966, 4, 275-285.

Kimura, D. The Asymmetry of the Human Brain. Scientific American, 1973, 228, 3, 70-78. (a).

Kimura, Doreen. Manual Activity during Speaking - I. Right-Handers. Neuropsychologia, 1973, 11, 45-50. (b).

Kimura, Doreen. Manual Activity during Speaking - II. Left-Handers. Neuropsychologia, 1973, 11, 51-55. (c).

Kinsbourne, M. and Warrington, E. Developmental Factors in Reading and Writing Backwardness. Brit. J. Psychol., 1963, 54, 145-156.

Kinsbourne, Marcel and Warrington, Elizabeth K. Developmental Factors in Reading and Writing Backwardness. In Money, J. (Ed.) The Disabled Reader: Education of the Dyslexic Child. Baltimore: Johns Hopkins, 1966.

Kirk, S.A. and Kirk, Winifred D. Psycholinguistic Learning Disabilies: Diagnosis and Remediation. Urbana, Ill.: University of Illinois Press, 1971.

Kirk, S.A. and McCarthy, J.J. The Illinois Test of Psycholinguistic Abilities - an Approach to Differential Diagnosis. Amer. J. Mental Deficiency, 1961, 66, 3, 399-412.

Kirk, S.A., McCarthy, J.J. and Kirk, Winifred. Examiner's Manual: Illinois Test of Psycholinguistic Abilities (Rev. Ed.). Urbana, Ill.: University of Illinois Press, 1968.

Kline, Carl L. and Lee, Norma. A Transcultural Study of Dyslexia: Analysis of Reading Disabilities in 425 Chinese Children Simultaneously Learning to Read and Write in English and in Chinese. Orton Society Bulletin, 1969, 19, 67-81.

Kline, Carl L. and Lee, Norma. A Transcultural Study of Dyslexia: Analysis of Language Disabilities in 277 Chinese Children Simultaneously Learning to Read and Write in English and in Chinese. J. Special Ed., 1972, 6, 1, 9-26.

Knox, A.W. and Boone, D.R. Auditory Laterality and Tested Handedness. Cortex, 1970, 6, 164-173.

Kolers, P.A. Reading Temporally and Spatially Transformed Text. In Goodman, K. (Ed.) The Psycholinguistic Nature of the Reading Process. Detroit: Wayne State University Press, 1968, pp. 27-40.

Kolers, P.A. Reading is only Incidentally Visual. In Goodman, K.S. and Fleming, J.T. (Eds.) Psycholinguistics and the Teaching of Reading. Newark, Delaware: International Reading Association, 1969, pp. 8-16.

Kolers, P.A. Three Stages of Reading. In Levin, H. and Williams, J.P. (Eds.) Basic Studies on Reading. New York: Basic Books, 1970, 90-118.

Kolers, Paul A. and Katzman, Martin T. Naming Sequentially Presented Letters and Words. Language and Speech, 1966, 9, 84-95.

Koppitz, Elizabeth M. The Bender Gestalt Test for Young Children. New York: Grune and Stratton, 1964.

Koppitz, Elizabeth M. Brain Damage, Reading Disability and the Bender Gestalt Test. J. Learning Disabilities, 1970, 3, 9, 6-10.

Koppitz, Elizabeth Munsterberg. Children with Learning Disabilities: A Five Year Follow-up Study. New York: Grune and Stratton, 1971.

Krashen, S.D. Lateralization, Language Learning, and the Critical Period: some New Evidence. Language Learning: a Journal of Applied Linguistics, 1973, 23, 1, 63-74.

Kuhn, Gary M. The Phi Coefficient as an Index of Ear Differences in Dichotic Listening. The Haskins Laboratories Status Report on Speech Research, SR-29/30. January-June, 1972, 75-82.

Lashley, K.S. The Mechanism of Vision: XV. Preliminary Studies of the Rat's Capacity for Detailed Vision. J. Gen. Psychol., 1938, 18, 123-193.

Lashley, K.S. The Problem of Serial Order in Behaviour. In Jeffreys, L.A. (Ed.) Cerebral Mechanisms in Behaviour: the Hixon Symposium. New York: Wiley, 1951.

Lenneberg, Eric H. A Biological Perspective of Language. In Lenneberg, Eric H. (Ed.) New Directions in the Study of Language. Cambridge, Mass.: the M.I.T. Press, 1964, (Paperback Ed., 1968, pp. 65-88).

Lenneberg, Eric H. Biological Foundations of Language. New York: Wiley, 1967.

Leong, C.K. A strategy for Transcultural Studies of Early Reading in the Alphabetic and Ideographic Systems. Paper read at XIII Inter-American Congress of Psychology, Panama City, Republic of Panama, December, 1971.

Leong, C.K. An Oblique Glance at Reading Disability. Orton Society Bulletin, 1972, 22, 69-79. (a).

Leong, C.K. A Study of Written Chinese Vocabulary. The Modern Language Journal, 1972, 56, 4, 230-234. (b).

Leong, C.K. Language Differences and Reading Disabilities. Paper read at the Symposium "Comparative Reading," International Reading Association 17th Annual Convention, Detroit, U.S.A., May, 1972. (c).

Leong, C.K. Reading in Chinese with Reference to Reading Practices in Hong Kong. In Downing, John (Ed.) Comparative Reading: Cross-National Studies of Behaviour and Processes in Reading and Writing. New York: Macmillan, 1973, 383-402. (a).

Leong, C.K. Aspects of Reading Difficulties. Journal of Education, the Chinese University of Hong Kong, 1973, 4, 91-104.

Leong, C.K. If the Model Fits - an Analysis of the Structure of the Revised Illinois Test of Psycholinguistic Abilities for Moderately Mentally Retarded Children. The Slow Learning Child, 1974 (in press). (a).

Leong, C.K. Language Behaviour of Moderately Mentally Retarded Children. In Das, J.P. and Baine, D. (Eds.) Mental Retardation for Special Educators. Springfield, Ill.: Charles C. Thomas, 1974. (in press). (b).

Leong, C.K. Comparison of Languages in Early Reading. 1975 (in preparation).

Lesser, G.S., Fifer, G., Clark, D.H. Mental Abilities of Children in Different Social and Cultural Groups. Monographs of the Society for Research in Child Development, 1965, 30, 4.

Levin, Harry. Project Literacy Reports, Numbers 1-8. Ithaca, New York: Cornell University Press, 1964-1967.

Levin, Harry and Williams, Joanna P. (Eds.) Basic Studies on Reading. New York: Basic Books, 1970.

Levy-Agresti, J. and Sperry, R.W. Differential Perceptual Capacities in Major and Minor Hemispheres. Paper presented at Fall Meeting, National Academy of Sciences, November 1968, Calif. Inst. of Tech., Pasadena, Calif. Proceedings of the National Academy of Sciences, 1968, 61, 1151.

Liberman, A.M. The Grammars of Speech and Language. Cognitive Psychology, 1970, 1, 301-323.

Liberman, A.M., Cooper, F.S., Shankweiler, D.P., and Studdert-Kennedy, M. Perception of the Speech Code. Psychological Review, 1967, 74, 6, 431-461.

Liberman, Isabelle Y. Speech and Lateralization of Language. Orton Society Bulletin, 1971, 21, 71-86.

Liberman, Isabelle Y. Segmentation of the Spoken Word and Reading Acquisition. The Haskins Laboratories Status Report on Speech Research SR-33, January-March, 1973.

Liberman, Isabelle Y., Shankweiler, D., Carter, Bonnie, and Fischer, F.W. Reading and the Awareness of Linguistic Segments. The Haskins Laboratories Status Report on Speech Research, SR-31/32, July-December, 1972.

Liberman, Isabelle Y., Shankweiler, D., Orlando, C., Harris, Katherine S., and Berti, F.B. Letter Confusions and Reversals of Sequence in the Beginning Reader: Implications for Orton's Theory of Developmental Dyslexia. Cortex, 1971, 7, 2, 127-142.

Ling, Agnes H. Dichotic Listening in Hearing-Impaired Children. J. Speech Hear. Research, 1971, 14, 4, 793-803.

Lord, Frederick M. Large-Sample Covariance Analysis When the Control Variable is Fallible. J. American Statistical Association, 1960, 55, 307-321.

Lowe, A. and Campbell, R. Temporal Discrimination in Aphasoid and Normal Children. J. Speech Hear. Res., 1965, 8, 313-314.

Lowe, Sena S., Cullen J.K., Jr., Berlin, C.I., Thompson, C.L., and Willett, Mary E. Perception of Simultaneous Dichotic and Monotic Monosyllables. Journal of Speech and Hearing Research, 1970, 13, 812-822.

Lubin, Ardie. The Interpretation of Significant Interaction. Ed. Psychol. Measurement, 1961, 21, 4, 807-817.

Luria, A.R. Experimental Study of the Higher Nervous Activity of the Abnormal Child. Journal of Mental Deficiency Research, 1959, 3, 1-22.

Luria, A.R. The Role of Speech in the Regulation of Normal and Abnormal Behaviour. London: Pergamon, 1961.

Luria, A.R. Neuropsychological Analysis of Focal Brain Lesions. In Wolman, Benjamin B. (Ed.) Handbook of Clinical Psychology. New York: McGraw-Hill, 1965, 689-754. (a).

Luria, A.R. L.S. Vygotsky and the Problem of Localization of Functions. Neuropsychologia, 1965, 3, 387-392. (b).

Luria, A.R. Higher Cortical Functions in Man. New York: Basic Books, 1966. (a).

Luria, A.R. Human Brain and Psychological Processes. New York: Harper and Row, 1966. (b).

Luria, A.R. Neuropsychology as a Science. In Proceedings of the XVIth International Congress of Applied Psychology, Amsterdam, August, 1968. Amsterdam: Swetz and Zeitlinger, 1969. pp. XLVII-LX.

Luria, A.R. The Functional Organization of the Brain. Scientific American, 1970, 222, 3, 66-78. (a).

Luria, A.R. Traumatic Aphasia: its Syndromes, Psychology and Treatment. The Hague: Mouton, 1970. (b).

Luria, A.R. Aphasia Reconsidered. Cortex, 1972, 8, 1, 34-40.

Luria, A.R. The Working Brain: an Introduction to Neuropsychology. London: Penguin, 1973.

Lyle, J.G. Performance of Retarded Readers on the Memory-for-Designs Test. Percept. Motor Skills, 1968, 26, 851-854.

Lyle, J.G. and Goyen, J. Performance of Retarded Readers on the WISC and Educational Tests. J. Abn. Psychol., 1969, 74, 105-115.

Maccoby, Eleanor E. Sex Differences in Intellectual Functioning. In Maccoby, Eleanor E. (Ed.) The Development of Sex Differences. Stanford, Calif.: Stanford University Press, 1966.

Maccoby, Eleanor E. Selective Auditory Attention in Children. In Lipsitt, Lewis P. and Spiker, Charles C. (Eds.) Advances in Child Development and Behavior, Vol. 3. New York: Academic Press, 1967. 99-124.

Maccoby, E.E. What Copying Requires. Ontario Journal of Educational Research, 1968, 10, 3, 163-170.

Maccoby, Eleanor E. and Jacklin, Carol N. Sex Differences in Intellectual Functioning. In Assessment in a Pluralistic Society: Proceedings of the 1972 Invitational Conference on Testing Problems. Princeton, New Jersey: Educational Testing Service, 1973, pp. 37-55.

Maccoby, E.E. and Konrad, K.W. Age Trends in Selective Listening. J. Experimental Child Psychology, 1966, 3, 113-122.

Maccoby, E.E. and Konrad, K.W. The Effect of Preparatory Set on Selective Listening: Developmental Trends. Monographs of the Society for Research in Child Development, 1967, 32 (No. 4, Serial No. 112).

Makita, Kiyoshi. The Rarity of Reading Disability in Japanese Children. Amer. J. Orthopsychiatry, 1968, 38, 599-614.

Mann, Lester. Perceptual Training: Misdirections and Redirections. Amer. J. Orthopsychiatry, 1970, 40, 1, 30-38.

Mann, Lester and Phillips, W. Fractional Practices in Special Education, Exceptional Children, 1967, 34, 311-317.

Masland, Richard L. Brain Mechanisms underlying the Language Function. Orton Society Bulletin Reprint No. 18, 1966.

Masland, Richard L. Lacunae and Research Approaches to Them, III. In Darley, Frederic L. (Ed.) Brain Mechanisms underlying Speech and Language. New York: Grune and Stratton, 1967, pp. 232-235.

Masland, Richard L. Some Neurological Processes underlying Language. Annals of Otology, Rhinology, and Laryngology, 1968, 77, LXIV, 787-804.

Masland, Richard L. Children with Minimal Brain Dysfunction - a National Problem. In Tarnopol, Lester (Ed.) Learning Disabilities: Introduction to Educational and Medical Management. Springfield, Ill.: Charles C. Thomas, 2nd Printing, 1970.

Mason, A.W. Specific (Developmental) Dyslexia. Develop. Med. Child Neurology, 1967, 9, 183-190.

Mathews, Milford H. Teaching to Read: Historically Considered. Chicago: Chicago University Press, 1966.

Mattingly, I.G. Reading, the Linguistic Process, and Linguistic Awareness. In Kavanagh, J.F. and Mattingly, I.G. (Eds.) Language by Ear and by Eye: the Relationships between Speech and Reading. Cambridge, Mass.: the M.I.T. Press, 1972, 133-147.

Maxwell, A.E. A Factor Analysis of the Wechsler Intelligence Scale for Children. Br. J. Ed. Psychol., 1959, 29, 237-241.

Maxwell, A.E. Factor Analysis: Thomson's Sampling Theory Recalled. Br. J. Math. Statist. Psychol., 1972, 25, 1-21. (a).

Maxwell, A.E. The WPPSI: a Marked Discrepancy in the Correlations of the Subtests for Good and Poor Readers. Br. J. Math. Statist. Psychol., 1972, 25, 283-291. (b).

McCall, Robert B., and Appelbaum, Mark I. Bias in the Analysis of Repeated Measures Designs: Some Alternative Approaches. Child Development, 1973, 44, 3, 401-415.

McCarthy, D. Some Possible Explanations of Sex Differences in Language Development and Disorders. Journal of Psychology, 1953, 35, 155-160.

McCarthy, D. Language Development in Children. In Carmichael, L. (Ed.) *Manual of Child Psychology*. (2nd Ed.) New York: Wiley, 1954. pp. 492-630.

McFie, J. Psychological Testing in Clinical Neurology. *J. Nerv. Ment. Dis.*, 1960, 131, 383-393.

McFie, J. Factors of the Mind. *Brit. Psychol. Soc. Bulletin*, 1972, 25, 86, 11-14.

McLeod, J. *Some Psychological and Psycholinguistic Correlates of Severe Reading Disability in Children.* Unpublished Doctoral Dissertation, University of Queensland, 1965.

McLeod, J. Some Psychlinguistic Correlates of Reading Disability in Young Children. *Reading Res. Quart.*, 1967, 2, 3, 5-31.

McLeod, J. Reading Expectancy from Disabled Readers. *J. Learning Disabilities*, 1968, 1, 97-104. (a).

McLeod, J. (Ed.) *The Slow Learner in the Primary School*. Sydney, Australia: Ian Novak, 1968. (b).

McLeod, John. *Dyslexia Schedule and School Entrance Check List Manual.* Cambridge, Mass.: Educators Pub. Service, 1969.

McLuhan, M. *Understanding Media: the Extensions of Man*. Toronto: McGraw-Hill, 1964.

McNeill, David. *The Acquisition of Language: the Study of Developmental Psycholinguistics*. New York: Harper and Row, 1970.

McNemar, Q. Sampling in Psychological Research. *Psychological Bulletin*, 1940, 37, 331-365.

Miller, G.A. The Magical Number Seven, Plus or Minus Two. *Psychol. Review*, 1956, 63, 81-97.

Miller, G.A., Galanter, E. and Pribram, K.H. *Plans and the Structure of Behavior*. New York: Henry Holt, 1960.

Milner, A.D. and Bryant, P.E. Cross-Modal Matching by Young Children. *Journal of Comparative and Physiological Psychology*, 1970, 71, 453-458.

Milner, B. Memory and the Medial Temporal Regions of the Brain. In Pribram, K.H. and Broadbent, D.E. (Eds.) *Biology of Memory*. New York: Academic Press, 1970.

Milner, B., Taylor, L., and Sperry, R.W. Lateralized Suppression of Dichotically presented Digits after Commissural Section in Man. *Science*, 1968, 161, 3837, 184-186.

Ministry of Education. Standards of Reading 1948 to 1956. (Pamphlet No. 32) London: H.M. Stationery Office, 1957.

Money, John. Dyslexia: a Postconference Review. In Money, John (Ed.) Reading Disability: Progress and Research Needs in Dyslexia. Baltimore: The Johns Hopkins Press, 1962.

Money, John. Two Cytogenetic Syndromes - Psychologic Comparison: I Intelligence and Specific Factor Quotients. Journal of Psychiatric Research, 1964, 2, 223-231.

Money, John. On Learning and Not Learning to Read. In Money, John (Ed.) The Disabled Reader: Education of the Dyslexic Child. Baltimore: The Johns Hopkins Press, 1966, pp. 21-40.

Money, John. The Laws of Constancy and Learning to Read. In Ass'n. for Children with Learning Disabilities. International Approach to Learning Disabilities of Children and Youth. San Rafael, Calif.: Academic Therapy Pub., 1967, pp. 80-97.

Monroe, M. Methods for Diagnosis and Treatment of Cases of Reading Disability. Genet. Psychol. Monog., 1928, 4, Nos. 4 and 5.

Monroe, M. Children who Cannot Read. Chicago: University of Chicago Press, 1932.

Monsees, E. Aphasia in Children. J. Speech Hear. Disord., 1961, 26, 83-86.

Moray, Neville. Broadbent's Filter Theory: Postulate H and the Problem of Switching Time. Quarterly Journal of Experimental Psychology, 1960, 12, 214-220.

Moray, N. Where is Capacity Limited: A Survey and a Model. Acta Psychologica, 1967, 27, 84-92.

Moray, N. Listening and Attention. Baltimore: Penguin, 1969. (a).

Moray, N. Attention: Selective Processes in Vision and Hearing. London: Hutchinson, 1969. (b).

Moray, N. and Barnett, T.J. Stimuls Presentation and Methods of Scoring in Short-term Memory Experiments. Acta Psychologica, 1965, 24, 253-263.

Moray, Neville, Bates, A. and Barnett, T. Experiments on the Four-Eared Man. J. Acoustic.Soc. Amer., 1965, 38, 196-201.

Moray, N. and Jordan, Ann. Practice and Compatibility in 2-Channel Short-term Memory. Psychonomic Science, 1966, 4, 12, 427-428.

Morrell, Lenore E. and Salamy, Joseph G. Hemispheric Asymmetry of Electro-Cortical Responses to Speech Stimuli. Science, 1971, 174, 4005, 164-166.

Morris, Joyce M. Reading in the Primary School. London: Newnes, 1959.

Morris, Joyce M. Standards and Progress in Reading. Slough: National Foundation for Educational Research in England and Wales (NFER), 1966.

Morrison, D.F. Multivariate Statistical Methods. New York: McGraw-Hill, 1967.

Muehl, S. and Kremenak, S. Ability to Match Information Within and Between Auditory and Visual Sense Modalities and Subsequent Reading Achievement. Journal of Educational Psychology, 1966, 57, 4, 230-239.

Mulaik, Stanley A. The Foundations of Factor Analysis. New York: McGraw-Hill, 1972.

Myklebust, H.R. Auditory Disorders in Children: A Manual for Differential Diagnosis. New York: Grune and Stratton, 1954.

Myklebust, H.R. (Ed.) Progress in Learning Disabilities: Volume I. New York: Grune and Stratton, 1968.

Myklebust, H.R. Learning Disabilities: Definition and Overview. In Myklebust, H.R. (Ed.) Progress in Learning Disabilities: Volume II. New York: Grune and Stratton, 1971, pp. 1-15.

Myklebust, H.R. (Ed.) Progress in Learning Disabilities: Volume II. New York: Grune and Stratton, 1971.

Myklebust, H.R. and Boshes, B. Minimal Brain Damage in Children. Final Report, Contract No. 108-65-142. Washington, D.C.: U.S. Department of Health, Education, and Welfare Neurological and Sensory Disease Control Program, 1969.

Naidoo, Sandhya. Specific Dyslexia: The Research Report of the ICAA Word Blind Centre for Dyslexic Children. London: Pitman, 1972.

National Advisory Committee on Handicapped Children. First Annual Report, Sub-Committee on Education of the Committee on Labor and Public Welfare, U.S. Senate. Washington, D.C.: U.S. Government Printing Office, 1968.

Neale, Marie. Neale Analysis of Reading Ability. London: Macmillan, 1958.

Neisser, U. Cognitive Psychology. New York: Appleton-Century-Crofts, 1967.

Neufeldt, Aldred H. Short-Term Memory in the Mentally Retarded: an Application of the Dichotic Listening Technique. Psych. Monog., 1966, 80, 12. (Whole No. 620).

Neville, D. A Comparison of the WISC Patterns of Male Retarded and Non-Retarded Readers. J. Ed. Res., 1961, 54, 5, 195-197.

Newell, A. A Note on Process-Structure Distinctions in Developmental Psychology. In Farnham-Diggory, Sylvia (Ed.) Information Processing in Children. New York: Academic Press, 1972, 126-139.

Newell, A., Shaw, I.C., and Simon, H.A. Elements of a Theory of Human Problem Solving. Psychological Review, 1958, 65, 3, 151-166.

Olson, David R. Cognitive Development: the Child's Acquisition of Diagonality. New York: Academic Press, 1970.

Orlando, C.P. Measures of Handedness as Indicators of Language Lateralization. Orton Society Bulletin, 1972, 22, 14-26.

Orn, D.E. and Das, J.P. IQ, Socio-Economic Status, and Short-term Memory. Journal of Educational Psychology, 1972, 63, 4, 327-333.

Orton, S.T. "Word Blindness" in School Children. Archives of Neurology and Psychiatry, 1925, 14, 581-615.

Orton, S.T. The "Sight Reading" Method of Teaching Reading Disability. J. Ed. Psychol., 1929, 20, 135-143.

Orton, S.T. Reading, Writing and Speech Problems in Children. (The Salmon Memorial Lectures). New York: W.W. Norton, 1937.

Orton, S.T. Visual Functions in Strephosymbolia. Arch. Ophth., 1943, 30, 707-717.

Osgood, C.E. A Behavioristic Analysis of Perception and Meaning as Cognitive Phenomena. In Contemporary Approaches to Cognition. Cambridge, Mass.: Harvard University Press, 1957, 75-118. (a).

Osgood, C.E. Motivational Dynamics of Language Behaviour. In Jones, M.R.(Ed.) Nebraska Symposium on Motivation. Lincoln, Nebraska: University of Nebraska Press, 1957, 348-424. (b).

Owen, Freya Weaver, Adams, Pauline Austin, Forest, T., Stolz, Lois Meek, and Fisher, Sara. Learning Disorders in Children: Sibling Studies. Monographs of the Society for Research in Child Development, Serial No. 144, 1971, 36, 4.

Paraskevopoulos, John N. and Kirk, Samuel A. The Developmental and Psychometric Characteristics of the Revised Illinois Test of Psycholinguistic Abilities. Urbana, Ill.: University of Illinois Press, 1969.

Parker, J.L. Need for New Strategies for Identification and Assessment of Mental Retardation. The Slow Learning Child, 1971, 18, 3, 131-141.

Pasamanick, B. and Kawi, A. A Study of the Association of Prenatal and Paranatal Factors with the Development of Tics in Children. J. Pediatrics, 1956, 48, 596-601.

Pasamanick, B. and Knobloch, H. Retrospective Studies on the Epidemiology of Reproductive Casualty: Old and New. Merrill-Palmer Quarterly. 1966, 12, 7-26.

Pasamanick, B. and Lilienfeld, A.M. Association of Maternal and Fetal Factors with Development of Mental Deficiency: I. Abnormalities in the Prenatal and Paranatal Periods. J. Amer. Medical Ass'n., 1955, 159, 155-160. (a).

Pasamanick, B. and Lilienfeld, A.M. Maternal and Fetal Factors in the Development of Epilepsy: II Relationships to some Clinical Features of Epilepsy. Neurology, 1955, 5, 77-83. (b).

Penfield, W. and Perot, P. The Brain's Record of Auditory and Visual Experience. Brain, 1963, 86, 4, 595-696.

Penfield, W. and Roberts, L. Speech and Brain Mechanisms. Princeton: Princeton University Press, 1959.

Pensom, Coombe F. The Computer as a Cytological Tool. Canad. Research and Development, May-June, 1971, 31-34.

Piaget, J. The Language and Thought of the Child. London: Routledge and Kegan Paul, 1926.

Piaget, J. and Inhelder, B. The Child's Conception of Space. Routledge and Kegan Paul (Translated by Langdom, F.J. and Lunzer, J.L.), 1956.

Piercy, Malcolm. The Effects of Cerebral Lesions on Intellectual Function: a Review of Current Research Trends. B.J. Psychiat., 1964, 110, 310-352.

Poeck, K. and Orgass, B. Gerstmann's Syndrome and Aphasia. Cortex, 1967, 3, 421-437.

Poor, D.D. Analysis of Variance for Repeated Measures Designs: Two Approaches. Psych. Bull., 1973, 80, 3, 204-209.

Premack, David and Schwartz, Arthur. Preparations for Discussing Behaviorism with Chimpanzee. In Smith, Frank and Miller, George A. (Eds.) The Genesis of Language: a Psycholinguistic Approach. Cambridge, Mass.: M.I.T. Press, 1966.

Premack, Ann James and Premack, David. Teaching Language to an Ape. *Scientific American*, 1972, 227, 4, 92-99.

Pribram, K.H. Four R's of Remembering. In Pribram, K.H. (Ed.) *On the Biology of Learning*. New York: Harcourt, Brace and Jovanovich, 1969, 193-225.

Pribram, K.H. The Brain. *Psychology Today*, 1971, 5, 4, 44-48, 88-90. (a).

Pribram, K.H. *Languages of the Brain: Experimental Paradoxes and Principles in Neuropsychology*. Englewood Cliffs, New Jersey: Prentice-Hall, 1971. (b).

Prick, J.J.G. *Infantile Autistic Behaviour and Experience: a New Clinical Picture*. Rotterdam: Rotterdam University Press, 1971.

Pringle, M.L. Kellmer, Butler, N.R., and Davie, R. *11,000 Seven-Year-Olds*. London: Longman, 1966.

Quereshi, M.Y. The Invariance of Certain Ability Scores. *Educational and Psychological Measurement*, 1967, 27, 803-810.

Rabinovitch, Ralph D. Dyslexia: Psychiatric Considerations. In Money, John (Ed.) *Reading Disability: Progress and Research Needs in Dyslexia*. Baltimore: the Johns Hopkins Press, 1962.

Rand, Colleen W. Copying in Drawing: the Importance of Adequate Visual Analysis Versus the Ability to Utilize Drawing Rules. *Child Development*, 1973, 44, 47-53.

Raven, J.C. *Progressive Matrices (1938), Sets A, B, C, D, and E*. London: H.K. Lewis, 1938.

Raven, J.C. *Progressive Matrices (1947a), Sets A, Ab and B*. London: H.K. Lewis, 1947. (a).

Raven, J.C. *Progressive Matrices (1947b), Sets I and II (for Adults)*. London: H.K. Lewis, 1947. (b).

Raven, J.C. *Guide to the Coloured Progressive Matrices*. London: H.K. Lewis, 1965.

Raven, J.C. *Guide to the Standard Progressive Matrices*. London: H.K. Lewis, 1968.

Rawson, M.B. *Developmental Language Disability: Adult Accomplishments of Dyslexic Boys*. Baltimore: The Johns Hopkins Press, 1968.

Rees, Norma S. Auditory Processing Factors in Language Disorders: the View from Procrustes' Bed. *J. Speech Hear. Dis.*, 1973, 38, 3, 304-315.

Reger, Roger, Schroeder, W., and Ushold, K. *Special Education: Children with Learning Problems*. New York: Oxford University Press, 1968.

Richardson, D.H. and Knights, R.M. A Bibliography on Dichotic Listening. *Cortex*, 1970, 6, 2, 236-240.

Robinson, J.S. and Voneida, T.J. Qualitative Differences in Performance on Abstract Discriminations using One or both Hemispheres. *Exp. Neurology*, 1970, 26, 72-83.

Rosenberg, Sheldon. Problems of Language Development in the Retarded. In Haywood, H. Carl (Ed.) *Social-Cultural Aspects of Mental Retardation*. New York: Appleton-Century-Crofts, 1970, pp. 203-216.

Rosenzweig, M.R. Representaitons of the Two Ears at the Auditory Cortex. *Amer. J. Physiol.*, 1951, 167, 147-158.

Rossi, Gian Franco and Rosadini, Guido. Experimental Analysis of Cerebral Dominance in Man. In Darley, F.L. (Ed.) *Brain Mechanisms underlying Speech and Language*. New York: Grune and Stratton, 1967, 167-184.

Rozin, P., Poritsky, S., and Sotsky, R. American Children with Reading Problems can Easily Learn to Read English represented by Chinese Characters. *Science*, 1971, 171, 1264-1267.

Rubino, Carl A. A Simple Procedure for Constructing Dichotic Listening Tapes. *Cortex*, 1972, 8, 3, 335-338.

Ruddell, R.B. The Effect of Oral and Written Patterns of Language Structure on Reading Comprehension. *The Reading Teacher*, 1965, 18, 270-275.

Rudel, R.G. and Teuber, H.-L. Cross-modal Transfer of Shape Discrimination by Children. *Neuropsychologia*, 1964, 2, 1-8.

Rudnick, Mark, Sterritt, G.M., and Flax, Morton. Auditory and Visual Rhythm Perception and Reading Ability. *Child Development*, 1967, 38, 2, 581-587.

Rutter, M., Tizard, J., and Whitmore, K. (Eds.) *Education, Health and Behaviour*. London: Longman, 1970.

Rutter, M., and Yule, W. Specific Reading Retardation. In Mann, L. and Sabatino, D. (Eds.) *The First Review of Special Education*. Philadelphia, Pa.: Buttonwood Farms, 1973.

Sasanuma, Sumiko and Fujimura, Osamu. Selective Impairment of Phonetic and Non-Phonetic Transcription of Words in Japanese Aphasic Patients: Kana vs. Kanji in Visual Recognition and Writing. *Cortex*, 1971, 7, 1, 1-18.

Sasanuma, Sumiko and Fujimura, Osamu. An Analysis of Writing Errors in Japanese Aphasic Patients: Kanji vs. Kana Words. *Cortex*, 1972, 8, 3, 265-282.

Satz, P. Laterality Effects in Dichotic Listening. *Nature*, 1968, 218, 277-278.

Satz, P., Achenbach, K., Pattishall, E., and Fennell, E. Order of Report, Ear Asymmetry and Handedness in Dichotic Listening. *Cortex*, 1965, 1, 4, 377-396.

Satz, Paul and Nostrand, Gary K. Van. Developmental Dyslexia: an Evaluation of a Theory. In Satz, Paul and Ross, John J. (Eds.) *The Disabled Learner: Early Detection and Intervention.* Rotterdam: Rotterdam University Press, 1973, pp. 121-148.

Satz, P. and Ross, J.J. (Eds.) *The Disabled Learner: Early Detection and Intervention*. Rotterdam: Rotterdam University Press, 1973.

Satz, P. and Sparrow, S. Specific Developmental Dyslexia: a Theoretical Formulation. In Bakker, D.J. and Satz, P. (Eds.) *Specific Reading Disability: Advances in Theory and Method*. Rotterdam: University of Rotterdam Press, 1970, pp. 17-40.

Schilder, P. Congenital Alexia and its Relation to Optic Perception. *Journal of Genetic Psychology*, 1944, 65, 67-88.

Schonell, F.J. *Backwardness in the Basic Subjects*. Edinburgh: Oliver and Boyd, 1942 (4th Ed., 1948).

Schonemann, P.H. A Generalized Solution of the Orthogonal Procrustes Problem. *Psychometrika*, 1966, 31, 1-10.

Schulhoff, C. and Goodglass, H. Dichotic Listening, Side of Brain Injury and Cerebral Dominance. *Neuropsychologia*, 1969, 7, 149-160.

Semmes, J. Hemispheric Specialization: a Possible Clue to Mechanism. *Neuropsychologia*, 1968, 6, 11-26.

Semmes, J., Weinstein, S., Ghent, L., and Teuber, H.-L. *Somatosensory Changes after Penetrating Brain Wounds in Man.* Cambridge, Mass.: Harvard University Press, 1960.

Senf, G.M. Development of Immediate Memory for Bisensory Stimuli in Normal Children and Children with Learning Disorders. *Developmental Psychol*., 1969, 1, 6, Pt. 2, 1-28.

Senf, Gerald M. An Information-Integration Theory and its Application to Normal Reading Acquisition and Reading Disability. In Bryant, N. Dale and Kass, Corrine E. (Eds.) *Leadership Training Institute in Learning Disabilities*. Final Report, U.S. Office of Education. Project No. 127145. Washington, D.C.: U.S. Office of Education, 1972.

Senf, G.M. and Freundl, Pamela, C. Memory and Attention Factors in Specific Learning Disabilities. *J. Learning Disabilities*, 1971, 4, 2, 94-106.

Shankweiler, D. Effects of Temporal-Lobe Damage in Perception of Dichotically Presented Melodies. J. Comp. Physiol. Psychol., 1966, 62, 115-119.

Shankweiler, D. An Analysis of Laterality Effects in Speech Perception. In Horton, D.L. and Jenkins, James J. (Eds.) The Perception of Language. Columbus, Ohio: Charles E. Merrill, 1971, pp. 185-206.

Shankweiler, D., and Liberman, Isabelle Y. Misreading: a Search for Causes. In Kavanagh, J.F. and Mattingly, I.G. (Eds.) Language by Ear and Eye: The Relationships between Speech and Reading. Cambridge, Mass.: M.I.T. Press, 1972, pp. 293-317.

Shankweiler, D. and Studdert-Kennedy, M. Identification of Consonants and Vowels presented to Left and Right Ears. Quarterly Journal of Experimental Psychology, 1967, 19, Pt. 1, 59-63.

Shapiro, M.B. The Single Case in Fundamental Clinical Psychological Research, Br. J. Med. Psychol., 1961, 34, 255-262.

Shapiro, M.B. The Single Case in Clinical Psychological Research. J. Gen. Psychol., 1966, 74, 3-23.

Shapiro, M.B. Intensive Assessment of the Single Case: An Inductive-Deductive Approach. In Mittler, P. (Ed.) The Psychological Assessment of Mental and Physical Handicaps. London: Methuen, 1970, 645-666.

Simon, H.A. An Information Processing Theory of Intellectual Development. In Kessen, W. and Kuhlman, C. (Eds.) Thought in the Young Child. Monographs of the Society for Research in Child Development, 1962, 27, 2, 150-155.

Simon, H.A. The Sciences of the Artificial. Cambridge, Mass.: M.I.T. Press, 1969.

Simon, H.A. On the Development of the Processor. In Farnham-Diggory, Sylvia (Ed.) Information Processing in Children. New York: Academic Press, 1972, 3-22.

Simon, H.A. and Barenfeld, M. Information-Processing Analysis of Perceptual Processes in Problem Solving. Psychological Review, 1969, 76, 5, 473-483.

Simon, H.A. and Newell, A. Computer Simulation of Human Thinking and Problem Solving. In Kessen, W. and Kuhlman, C. (Eds.) Thought in the Young Child. Monographs of the Society for Research in Child Development, 1962, 2 (Whole No. 83), 137-150.

Singer, H. and Ruddell, R.B. (Eds.) Theoretical Models and Processes of Reading. Newark, Delaware: International Reading Association, 1970.

Skakun, E.N., Maguire, T.O., and Hakstian, A.R. An Application of Inferential Statistics to the Factorial Invariance Problem. Research and Information Report. Div. Ed. Research, University of Alberta, April, 1972.

Smith, Frank. The Use of Featural Dependencies Across Letters in the Visual Identification of Words. J. Verb. Learn Verb. Behav., 1969, 8, 215-218.

Smith, Frank. Understanding Reading: a Psycholinguistic Analysis of Reading and Learning to Read. New York: Holt, Rinehart and Winston, 1971.

Sparks, Robert and Geschwind, Norman. Dichotic Listening in Man After Section of Neocortical Commissures. Cortex, 1968, 4, 1, 3-16.

Sparrow, Sara, and Satz, Paul. Dyslexia, Laterality and Neuropsychological Development. In Bakker, Dirk J., and Satz, Paul (Eds.) Specific Reading Disability: Advances in Theory and Method. Rotterdam: Rotterdam University Press, 1970, pp. 41-60.

Spearman, C. The Abilities of Man. London: Macmillan, 1927.

Spellacy, Frank and Blumstein, Sheila. The Influence of Language Set on Ear Preference in Phoneme Recognition. Cortex, 1970, 6, 4, 430-439.

Sperling, G. A Model for Visual Memory Tasks. Human Factors, 1963, 5, 19-31.

Sperling, G. Short-Term Memory, Long-Term Memory, and Scanning in the Processing of Visual Information. In Young, Francis A. and Lindsley, Donald B. (Eds.) Early Experience and Visual Information Processing in Perceptual and Reading Disorders. Washington, D.C.: National Academy of Sciences, 1970, pp. 198-218.

Sperry, R.W. Cerebral Organization and Behavior. Science, 1961, 133, 1749-1757.

Sperry, R.W. The Great Cerebral Commissure. Scientific American, 1964, 210, 42-52.

Sperry, R.W. Hemispheric Disconnection and Unity in Conscious Awareness. Amer. Psychologist, 1968, 23, 723-733.

Sperry, R.W. Cerebral Dominance in Perception. In Young, F.A. and Lindsley, D.B. (Eds.) Early Experience and Visual Information Processing in Perceptual and Reading Disorders. Washington, D.C.: National Academy of Sciences, 1970, 167-178.

Spreen, O., Spellacy, F.J. and Reid, J.R. The Effect of Interstimulus Interval and Intensity on Ear Asymmetry for Nonverbal Stimuli in Dichotic Listening. *Neuropsychologia*, 1970, 8, 245-250.

Stanley, Julian C. Problems in Equating Groups in Mental Retardation Research. *J. Sp. Education*, 1967, 1, 3, 241-256.

Sterritt, G.M. and Rudnick, Mark. Auditory and Visual Rhythm Perception in Relation to Reading Ability in Fourth Grade Boys. *Percept. Motor Skills*, 1966, 22, 859-864.

Stevens, K.N. and Halle, M. Remarks on Analysis by Synthesis and Distinctive Features. In Wathan-Dunn, W. (Ed.) *Models for the Perception of Speech and Visual Form*. Cambridge, Mass.: the M.I.T. Press, 1967.

Stodolsky, S. and Lesser, G. Learning Patterns in the Disadvantaged. In Chess, S. and Thomas, A. (Eds.) *Annual Progress in Child Psychiatry and Child Development*. New York: Brunner/Mazel, 1968, pp. 224-272.

Strauss, A. and Lehtinen, L. *Psychopathology and Education of the Brain-Injured Child*. New York: Grune and Stratton, 1947.

Strickland, R.G. The Language of Elementary School Children: its Relationship to the Language of Reading Textbooks and the Quality of Reading of Selected Children. *Bull. of the School of Education, Indiana University*, 1962, 38, 1-131.

Studdert-Kennedy, M. and Shankweiler, D. Hemispheric Specialization for Speech Perception. *The Journal of the Acoustical Society of America*, 1970, 48, 2, Pt. 2, 579-594.

Studdert-Kennedy, M., Shankweiler, D., and Pisoni, D. Auditory and Phonetic Processes in Speech Perception: Evidence from a Dichotic Study. *Cognitive Psychology*, 1972, 3, 455-466.

Sutherland, N.S. Visual Discrimination of Orientation by Octopus: Mirror Images. *Brit. J. Psychol.*, 1960, 51, 9-18.

Sutherland, N.S. Cat's Ability to Discriminate Oblique Rectangles. *Science*, 1963, 139, 209-210.

Symmes, Jean S. Deficit Models, Spatial Visualization, and Reading Disability. *Orton Society Bulletin*, 1972, 22, 54-68.

Symmes, Jean S. and Rapoport, Judith L. Unexpected Reading Failure. *Amer. J. Orthopsychiatry*, 1972, 42, 1, 82-91.

Tanner, J.M. (Ed.) *Human Growth*. London: Pergamon, 1960.

Tanner, J.M., Prader, A., Habich, H., and Perguson-Smith, M.A. Genes on the y chromosome Influencing Rate of Maturation in Man: Skeletal Age Studies in Children with Klinefelter's (xxy) and Turner's (xo) syndromes. *Lancet*, 1959, 11, 141-144.

Tatsuoka, M.M. *Multivariate Analysis: Techniques for Educational and Psychological Research*. New York: Wiley, 1971.

Terman, L.M. and Tyler, L.E. Psychological Sex Differences. In Carmichael, L. (Ed.) *Manual of Child Psychology*, New York: Wiley, 1954.

Teuber, Hans-Lukas. Lacunae and Research Approaches to Them I. In Millikan, Clark H. and Darley, F.L. (Eds.) *Brain Mechanisms underlying Speech and Language*. New York: Grune and Stratton, 1967, 204-216.

Thompson, L.J. *Reading Disability: Developmental Dyslexic*. Springfield, Illinois: Charles C. Thomas, 1966.

Thomson, G.H. *The Factorial Analysis of Human Ability*. London: University of London Press, 1951.

Thorndike, Robert L. *The Concepts of Over- and Underachievement*. New York: Teachers College, Columbia University, 1963.

Thurstone, L.L. *Multiple-Factor Analysis*. Chicago: University of Chicago Press, 1947.

Thurstone, L.L. Implications of Factor Analysis. *Amer. Psychologist*. 1948, 3, 402-408.

Thurstone, L.L. *The Differential Growth of Mental Abilities*. Chapel Hill, North Carolina: University of North Carolina Psychometric Laboratory, 14, 1955.

Tinker, M.A. Eye Movements in Reading. *Journal of Educational Research*, 1936, 30, 241-277.

Treisman, A.M. Contextual Cues in Selective Listening. *Quart. J. Exp. Psychol.*, 1960, 12, 242-248.

Treisman, A.M. Selective Attention in Man. *Brit. Med. Bull.*, 1964, 20, 12-16.

Treisman, A.M. Strategies and Models of Selective Attention. *Psychol. Review*, 1969, 76, 282-299.

Treisman, Anne M. Perception and Recall of Simultaneous Speech Stimuli. *Acta Psychologica*, 1970, 33, 132-148.

Treisman, Anne M. and Fearnley, J.S. Can Simultaneous Speech Stimuli be Classified in Parallel? *Perception and Psychophysics*, 1971, 10, 1-7.

Treisman, A.M. and Geffen, G. Selective Attention: Perception or Response. *Quart. J. Exp. Psychol.*, 1967, 19, 1-17.

Treisman, A.M. and Riley, G.A. Is Selective Attention Selective Perception or Selective Response? J. Exp. Psychol., 1969, 79, 27-34.

Tukey, John W. Analyzing data: Sanctification or Detective Work? American Psychologist, 1969, 24, 2, 83-90.

Urbano, R.C. and Scott, K.G. Digit Span, Practice and Dichotic Listening Performance in the Mentally Retarded. J. Exp. Child Psychol., 1969, 8, 3, 432-442.

Van Meel, Jacques M., Vlek, Charles A.J. and Bruijel, Renske M. Some Characteristics of Visual Information-Processing in Children with Learning Difficulties. In Bakker, Dirk J. and Satz, Paul (Eds.) Specific Reading Disability: Advances in Theory and Method. Amsterdam: Rotterdam University Press, 1970.

Vande Voort, Lewis, Senf, Gerald M., and Benton, Arthur L. Development of Audiovisual Integration in Normal and Retarded Readers. Child Development, 1972, 43, 4, 1260-1272.

Venezky, R.L. English Orthography: Its Graphical Structure and its Relation to Sound. Reading Research Quarterly, 1967, 2, 75-106.

Venezky, Richard L. Regularity in Reading and Spelling. In Levin, Harry and Williams, Joanna P. (Eds.) Basic Studies on Reading. New York: Basic Books, 1970, pp. 30-42.

Vernon, M.D. Backwardness in Reading: a Study of Its Nature and Origin. Cambridge: Cambridge University Press, 1957.

Vernon, M.D. Specific Dyslexia. Brit. J. Ed. Psych., 1962, 32, Pt. 2, 143-150.

Vernon, M.D. Reading and its Difficulties: a Psychological Study. Cambridge: University Press, 1971.

Vernon, P.E. Psychological Tests in the Royal Navy, Army and A.T.S. Occupational Psychology, 1947, 21, 53-74.

Vernon, P.E. The Structure of Practical Abilities. Occupational Psychology, 1949, 23, 81-96.

Vygotsky, L.S. Thought and Language. Cambridge, Mass.: the M.I.T. Press, 1962.

Wada, J. and Rasmussen, T. Intracarotid Injection of Sodium Amytal for the Lateralization of Cerebral Speech Dominance: Experimental and Clinical Observations. J. Neurosurg., 1960, 17, 266-282.

Wagner, Rudolph F. Rudolf Berlin. Originator of the Term Dyslexia. Orton Society Bulletin, 1973, 23, 57-63.

Walker, James. Pregnancy and Peri-Natal Association with Mental Subnormality. In Meade, J.E. and Parkes, A.S. (Eds.) Genetic and Environmental Factors in Human Ability. New York: Plenum Press, 1966, pp. 105-120.

Wechsler, D. The Measurement and Appraisal of Adult Intelligence. (4th Ed.) Baltimore: Williams and Wilkins, 1958.

Wechsler, David. Manual for the Wechsler Intelligence Scale for Children - Revised. New York: Psych. Corp., 1974.

Weir, Ruth H. and Venezky, R.L. Spelling to Sound Patterns. (English Orthography - More Reason than Rhyme). In Goodman, K.S. (Ed.) The Psycholinguistic Nature of the Reading Process. Detroit: Wayne State University Press, 1968, pp. 185-199.

Wepman, Joseph M. A Conceptual Model for the Processes involved in Recovery from Aphasia. J. Speech and Hearing Disorders, March, 1953, 18, 4-13.

Wepman, Joseph M. Dyslexia: its Relationship to Language Acquisition and Concept Formation. In Money, J. (Ed.) Reading Disability: Progress and Research Needs in Dyslexia. Baltimore: Johns Hopkins, 1962, pp. 179-186.

Wepman, Joseph M. The Perceptual Basis for Learning. In Frierson, Edward C. and Barbe, Walter B. (Eds.) Educating Children with Learning Disabilities: Selected Readings. New York: Appleton-Century-Crofts, 1967, pp. 353-362.

Wepman, Joseph M. The Modality Concept. In Smith, Helen K. (Ed.) Perception and Reading. Newark, Delaware: International Reading Association, 1968, pp. 1-6.

Wertheimer, M. Productive Thinking. New York: Haper, 1957.

White, Murray J. Laterality Differences in Perception: a Review. Psychological Bulletin, 1969, 72, 6, 387-405.

Wickelgren, W.A. Context-Sensitive Coding, Associative Memory, and Serial Order in (Speech) Behavior. Psychological Review, 1969, 76, 1, 1-15.

Wiener, M., and Cromer, W. Reading and Reading Difficulty: a Conceptual Analysis. Harvard Educational Review, 1967, 37, 4, 620-643.

Wiener, N. Cybernetics. New York: Wiley, 1948.

Wilson, R.H., Dirks, D.D. and Carterette, E.C. Effects of Ear Preference and Order Bias on the Reception of Verbal Materials. J. Speech Hearing Res., 1968, 11, 3, 509-522.

Winer, B.J. Statistical Principles in Experimental Design. New York: McGraw-Hill, 1962.

Wiseman, S. Education and Environment. Manchester: Manchester University Press, 1964.

Wiseman, Stephen. Educational Deprivation and Disadvantage. In Butcher, H.J. (Ed.) Educational Research in Britain. London: University of London Press, 1968, pp. 261-281.

Wood, C.C., Goff, W.R.,and Day, Ruth S. Auditory Evoked Potentials during Speech Perception. Science, 1971, 173, 4003, 1248-1251.

Wortis, Joseph. Prevention of Mental Retardation. Amer. J. Orthopsychiatry, 1965, 35, 886-895.

Yates, A.J. Technical, Methodological and Theoretical Problems in Dichotic Stimulation Research. Australian Psychologist, 1972, 7, 1, 2-19.

Yates, A.J., Smith, P.J., Burke, B.D., and Keane, M.A. A Technique for the Construction of Discrete Dichotic Stimulation Material. Behav. Res. Methods & Instrumentation, 1969, 1, 257-258.

Yntema, D.B. and Trask, Frances P. Recall as a Search Process. J. Verbal Learning and Verbal Behavior, 1963, 2, 65-74.

Young, Francis A. and Lindsley, D.B. (Eds.) Early Experience and Visual Information Processing in Perceptual and Reading Disorders. Washington, D.C.: National Academy of Sciences, 1970.

Yule, W. Predicting Reading Ages on Neale's Analysis of Reading Ability. Br. J. Ed. Psychol., 1967, 37, Pt. 2, 252-255.

Yule, W. Differential Prognosis of Reading Backwardness and Specific Reading Retardation. British Journal of Educational Psychology, 1973, 43, 244-248.

Yule, W., Rutter, M., Berger, M., and Thompson, J. Over- and Under-Achievement in Reading: Distribution in the General Population. British Journal of Educational Psychology, 1974, 44, Pt. 1, 1-12.

Zangwill, O.L. Cerebral Dominance and its Relation to Psychological Function. Edinburgh: Oliver and Boyd, 1960.

Zangwill, O.L. Dyslexia in Relation to Cerebral Dominance. In Money, John (Ed.) Reading Disability: Progress and Research Needs in Dyslexia. Baltimore: The Johns Hopkins Press, 1962, pp. 103-113.

Zurif, E.B. and Bryden, M.P. Familial Handedness and Left-Right Differences in Auditory and Visual Perception. Neuropsychologia, 1969, 7, 179-187.

Zurif, E.B. and Carson, G. Dyslexia in Relation to Cerebral Dominance and Temporal Analysis. Neuropsychologia, 1970, 8, 351-361.

Zurif, E.B. and Sait, P.E. The Role of Syntax in Dichotic Listening. Neuropsychologia, 1970, 8, 239-244.

APPENDICES

APPENDIX A

Administrative Arrangement for Investigation

Post April, 1973

I.	May, June, July, 1973	Preparation of Dichotic Listening Tapes Testing of system of instrumentation; Preparation of tryout tapes, master tapes and of final tapes; Testing for synchrony of stimuli and inter-stimulus intervals with polygraph machine.
II.	Mid-August to late September, 1973	Sampling Initial selection of Experimental Group from records; Visits to schools - observation of children and consultation with principals and teachers; Selection of Control Group.
III.	October, 1973 to mid-January, 1974	In-Situ Experimentation 16 different schools with 58 disabled readers and 58 controls -- 55 school days or excess of 275 man/hours used.
IV.	February to early April, 1974	Data Analysis Flexible approach - different methods used where applicable (as in factor analysis).
V.	April, May, June to mid-July, 1974	Writing and Reporting Modifying of thesis proposal and re-writing from updated versions; Integration with data analysis and further writing of manuscript.

APPENDIX B

Dichotic Listening Experiment 1 (DL1)

Procedure of Administration and Test

I. Administration

Each child on arriving is seated at a table opposite the investigator and is briefly introduced to the use of the headphones. The investigator explains to the child that he will hear two different numbers together through the headphones, one in each ear and that he simply repeats all the numbers he hears. The child is further told that he will later hear series of 4, 6, 8 and 10 numbers together and is asked to do the best he can. With this verbatim explanation, the child then puts on the earphones through which he hears this instruction:

> "Now you are going to hear two numbers together, one number in the left ear and one number in the right ear. Tell me all the numbers that you hear."

The two channels then play the first practice example "3-7" or "7-3" simultaneously. This is followed by the other two examples. When the child is fully conversant with what is required of him, the test proper begins. The instruction preceding each set of 5 series of 2-digit pairs, 3-digit pairs, 4-digit pairs and 5-digit pairs is as follows:

> "Now you are going to hear [N] numbers together, [N/2] numbers in the left ear and [N/2] numbers (where N is 4, 6, 8 or 10) in the right ear. Tell me all the numbers that you hear."

The child's responses are recorded on proformas with test items on the left as shown.

II. Test

Examples

Left	Right	Left	Right
3	7	7	3
1	8	8	1
2	4	4	2
Test[1]			
2-7	5-3	5-3	2-7
4-6	1-8	1-8	4-6
5-8	3-2	3-2	5-8
7-4	9-1	9-1	7-4
3-8	6-9	6-9	3-8
4-7-5	6-1-3	6-1-3	4-7-5
6-5-9	7-4-2	7-4-2	6-5-9
8-6-1	2-5-7	2-5-7	8-6-1
3-4-6	5-8-3	5-8-3	3-4-6
9-3-1	8-7-9	8-7-9	9-3-1
3-7-5-2	9-1-2-3	9-1-2-3	3-7-5-2
4-8-1-6	5-1-6-4	5-1-6-4	4-8-1-6
8-9-3-1	2-7-5-3	2-7-5-3	8-9-3-1
6-3-2-9	8-5-6-4	8-5-6-4	6-3-2-9
2-4-3-6	7-1-5-2	7-1-5-2	2-4-3-6
4-8-2-5-6	2-9-8-3-5	2-9-8-3-5	4-8-2-5-6
2-7-4-2-3	5-6-1-4-2	5-6-1-4-2	2-7-4-2-3
4-6-3-2-9	8-5-2-3-7	8-5-2-3-7	4-6-3-2-9
8-7-4-9-3	2-6-9-5-4	2-6-9-5-4	8-7-4-9-3
1-9-6-2-5	6-4-3-8-1	6-4-3-8-1	1-9-6-2-5

---

[1] Note scoring as in Section 6.3 (a).

APPENDIX C

Dichotic Listening Experiment 2 (DL2)

Procedure of Administration and Test

I. Administration

The investigator begins by explaining to the child that the experiment consists of 12 dichotic items. Each item has 6 elements in all with 3 elements input to one ear and 3 elements input to the other ear simultaneously. There are always 3 digits and 3 letters of the alphabet selected from "A, E, I, O, U, Y, L, M, R, X". The investigator then repeats the 10 letters to the child, indicating that they are the vowels plus the consonants. The child then repeats the letters back. The investigator then says,

> "Now listen carefully. You are going to hear three numbers and three letters of the alphabet. The numbers and letters are mixed together like this: 'e-L-3' or like this: '7-1-y'. I want you to tell me what you hear in the left [right] ear first, then what you hear in the right [left] ear. Listen carefully to what I am going to tell you. Be sure to tell me all you hear in one ear (left/right) first and then all you hear in the other ear."

This is followed by the 5 practice samples (with further explanation if necessary) to ensure that the child knows what is required of him in reporting the dichotic elements by sides (ears).

II. Test

Examples

Left	Right	Left	Right
4-u-m	a-one-7	a-one-7	4-u-m
o-e-i	8-zero-6	8-zero-6	o-e-i
8-5-e	u-i-6	u-i-6	8-5-e
3-m-9	o-7-r	o-7-r	3-m-9
4-y-zero	x-3-u	x-3-u	4-y-zero
Test			
zero-3-4	L-o-i	L-o-i	zero-3-4
y-8-r	7-i-3	7-i-3	y-8-r
9-6-a	L-y-4	L-y-4	9-6-a
4-2-u	a-o-8	a-o-8	4-2-u
e-y-L	5-6-zero	5-6-zero	e-y-L
9-L-8	e-6-i	e-6-i	9-L-8
o-8-a	3-m-9	3-m-9	o-8-a
o-9-5	4-i-u	4-i-u	o-9-5
u-x-zero	7-2-y	7-2-y	u-x-zero
one-a-r	L-6-9	L-6-9	one-a-r
7-8-6	u-y-L	u-y-L	7-8-6
zero-r-y	e-9-4	e-9-4	zero-r-y

APPENDIX D

Dichotic Listening Experiment 3 (DL3)

Procedure of Administration and Test

I. Administration

The investigator begins by explaining to the child that the experiment consists of 12 dichotic items. Each item has 6 elements in all with 3 elements input to one ear and 3 elements input to the other ear simultaneously. There are always 3 digits and 3 letters of the alphabet selected from "A, E, I, O, U, Y, L, M, R, X". The investigator then repeats the 10 letters to the child, indicating that they are the vowels plus the consonants. The child then repeats the letters back. The investigator then says,

> "Now listen carefully. You are going to hear three numbers and three letters of the alphabet. The numbers and letters are mixed together like this: 'e-L-3' or like this: '7-1-y'. I want you to tell me all the letters [numbers] first, then the numbers [letters]. Listen carefully to what I am going to tell you. Be sure to tell me all the letters [numbers] first and then all the numbers [letters]."

This is followed by the 3 practice examples (with further explanation if necessary) to ensure that the child knows what is required of him in reporting the dichotic elements by types.

II. Test

Examples

Left	Right	Left	Right
9-a-5	x-2-4	x-2-4	9-a-5
e-L-3	7-one-y	7-one-y	e-L-3
zero-m-a	i-6-2	i-6-2	zero-m-a

Test

Left	Right	Left	Right
a-one-7	4-u-m	4-u-m	a-one-7
x-L-o	8-one-6	8-one-6	x-L-o
8-m-9	L-2-a	L-2-a	8-m-9
e-zero-a	5-y-9	5-y-9	e-zero-a
x-m-5	8-3-i	8-3-i	x-m-5
4-e-3	i-zero-x	i-zero-x	4-e-3
u-m-L	9-6-8	9-6-8	u-m-L
8-4-o	r-u-2	r-u-2	8-4-o
3-2-i	a-o-7	a-o-7	3-2-i
L-m-r	5-zero-2	5-zero-2	L-m-r
5-x-L	i-7-4	i-7-4	5-x-L
y-2-7	9-m-x	9-m-x	y-2-7

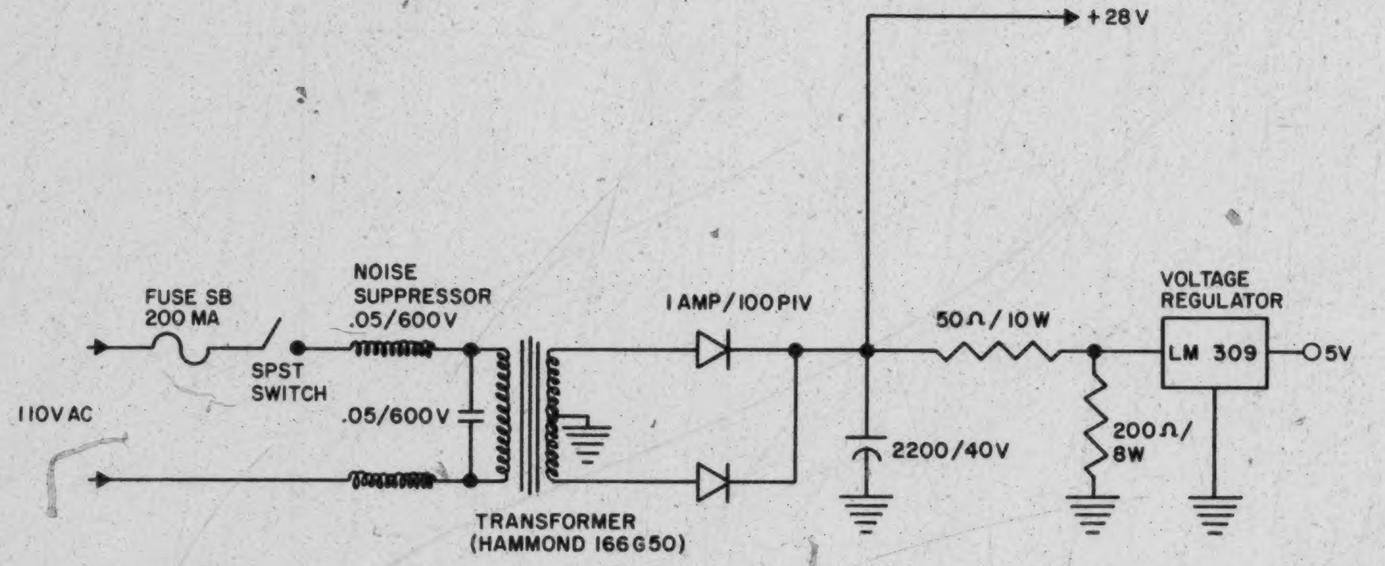
APPENDIX E

Description of Major Instrumentation

Sony TC-777-4J

Tape Speeds:	7 1/2 ips (19 cm/s) or 3 3/4 ips (9.5 cm/s), instantaneous switching
Signal-to-Noise Ratio:	50 dB or better
Flutter and Wow:	Less than 0.1% at 7 1/2 ips (19 cm/s)
Head Complements:	Electro-bilateral 4-track erase/ 4-track record, 2-track playback, 4-track playback
Inputs:	
Microphone	– 60 dB, 600 ohms (unbalanced)
Line	– 10 dB, high impedance (unbalanced)
Outputs:	
Line Output (Switched)	0 dB, low impedance (unbalanced) 0 dB, high impedance (unbalanced)
Stero Monitor	– 3 dB, high impedance (unbalanced)
Record/Playback Connector:	
Inputs	– 33 dB, load impedance 100 K ohms
Outputs	– 3 dB, load impedance 100 K ohms

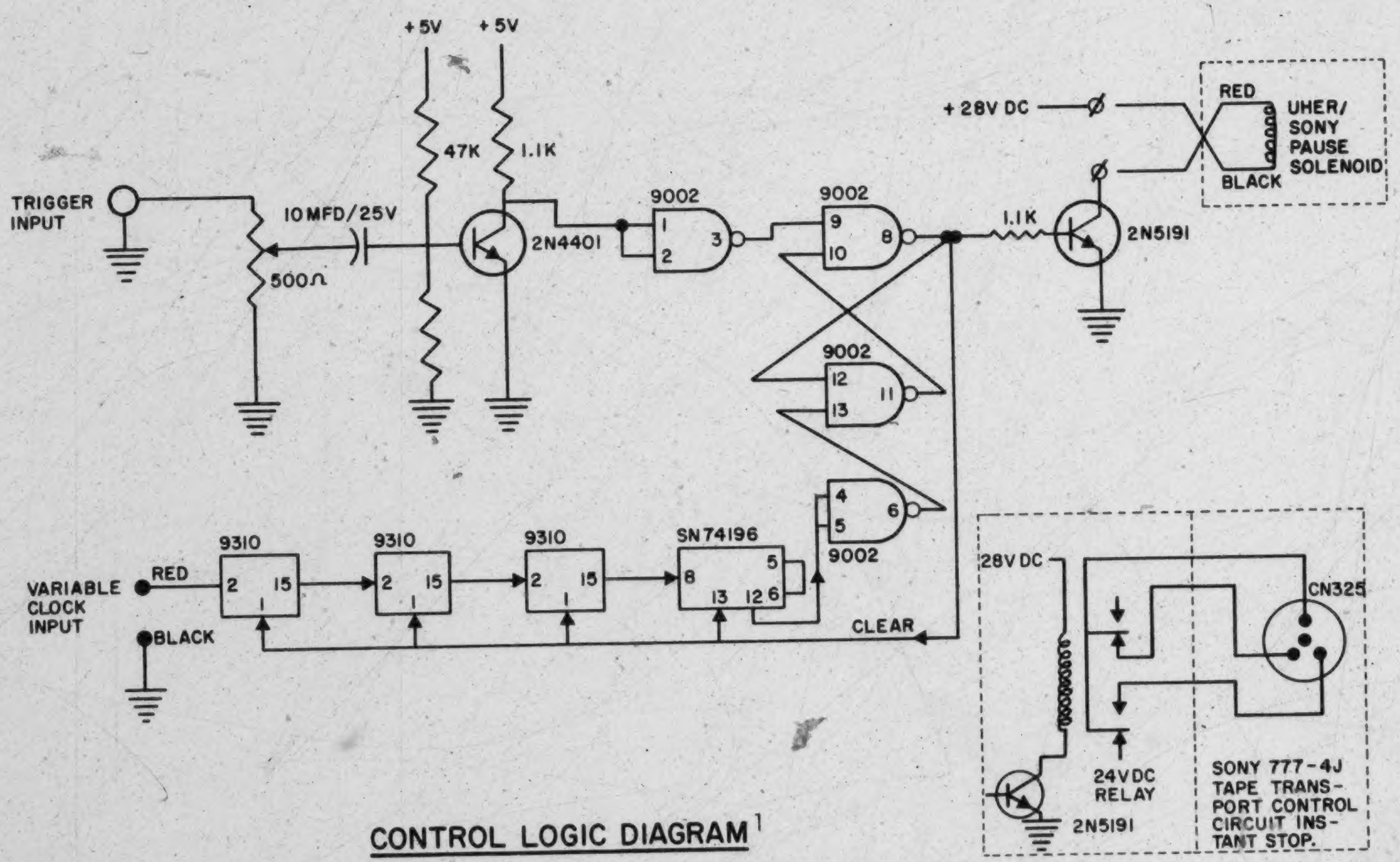
APPENDIX F



FUSE SB
200 MA
SPST
SWITCH
NOISE
SUPPRESSOR
.05/600V
.05/600V
110VAC
TRANSFORMER
(HAMMOND 166G50)
1 AMP/100PIV
+28V
2200/40V
50Ω/10W
200Ω/
8W
VOLTAGE
REGULATOR
LM 309
5V

POWER SUPPLY DIAGRAM

APPENDIX G


+5V
+5V
47K
1.1K
TRIGGER INPUT
10MFD/25V
500Ω
2N4401
9002
1
2
3
9002
9
10
8
1.1K
2N5191
+28V DC
RED
BLACK
UHER/ SONY PAUSE SOLENOID
9002
12
13
11
9002
4
5
6
VARIABLE CLOCK INPUT
RED
BLACK
9310
2
15
1
9310
2
15
1
9310
2
15
1
SN74196
8
13
12
5
6
CLEAR
28V DC
CN325
24VDC RELAY
2N5191
SONY 777-4J TAPE TRANSPORT CONTROL CIRCUIT INSTANT STOP.

CONTROL LOGIC DIAGRAM[1]

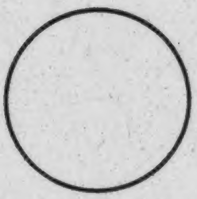
---

[1] Inset shows modification from Uher 8000 to Sony 777-4J.

APPENDIX H

Figure Copying Task (FCT)

1.



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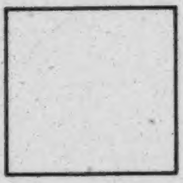

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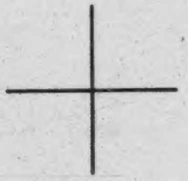

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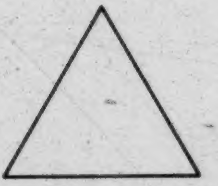

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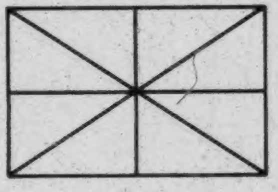

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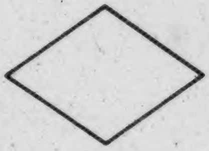

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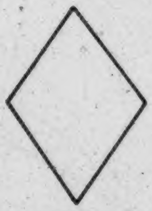

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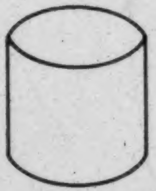

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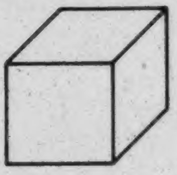

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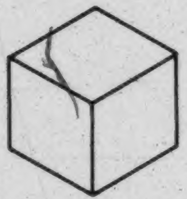


APPENDIX I

Figure Copying Test (FCT)

The child is asked to make an exact, free-hand copy of ten shapes: a circle, a square, a cross, a triangle, a rectangle with intersecting diagonals and mid-lines, a diamond in which length is 1.7 times height, a diamond in which height is 1.7 times length, a cylinder and two cuboids in different perspectives. No time limit is given. Each drawing is scored as 0, 1 or 2 according to the degree of correctness of the production. The total score is the sum of the scores for the individual drawings with a range from 0 to 20. The scoring criterion is one of exactitude of shape and not the absolute size of the drawing. These scoring principles apply:

I. General Principles for All Drawings:

1. The drawing must have the correct general shape and look like that which it is supposed to be.
2. The drawing should be approximately symmetrical.
3. Angles should not be rounded.
4. The drawing should not be rotated.
5. Angles must be approximately opposite each other (except for the triangle).
6. Slight bowing or irregularity of lines is allowed.
7. Lines should meet approximately, but as long as other criteria are met small gaps at junctions are acceptable.
8. Slight crossing and overlapping of lines is permitted.
9. If two attempts are made in a single drawing score for the worst one.
10. Provided other criteria are met, neatness is not important.

II. Scoring Principles Specific to Each Drawing:

1. Circle
   - a) No diameter of the circle may be as much as 1½ times as long as any other.
   - b) The drawing must not be angled.
   - c) Overlapping of curved lines is permitted.
2. Square
   - a) The angle must be approximately 90°.
   - b) The drawing must be symmetrical.
   - c) No side may be as much as 1½ times the length of any other side.
3. Cross
   - a) The drawing must be approximately 90°.
   - b) No side may be as much as 1½ times the length of any other side.
4. Triangle
   - a) No side may be as much as 1½ times as long as any other side.
   - b) There must be 3 well-defined angles.
5. Rectangle with intersecting Diagonals and Mid-Lines
   - a) The drawing must be rectangular with angles approximately 90°.
   - b) The diagonals must run from one corner to the opposite one.
   - c) The mid-lines, both horizontal and vertical, must run approximately in the middle of the drawing.
   - d) The diagonals and mid-lines should intersect one another at approximately the "mid-point" of the drawing.

6, 7. Diamonds

a) There must be 4 well-defined angles.

b) The drawing must be more diamond shaped than square or kite shaped.

c) The pairs of angles must be approximately opposite.

d) For drawing No (6) the length of the diamond should be approximately from 1½ to 2 times the height. For drawing No (7) this is reversed.

8. Cylinder

a) The diameters of the base and the top should be approximately equal and these in turn should be approximately the same as the height.

b) The base and the top lines should be curved.

9, 10. Cuboids in different Perspectives

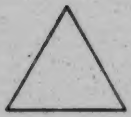
a) Proper perspective must be preserved as in the specimens.

b) Lengths, widths and heights should be approximately equal.

APPENDIX J

Memory-for-Designs Test (MFD)

1



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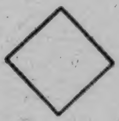

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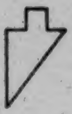

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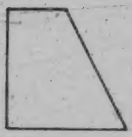

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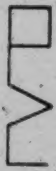

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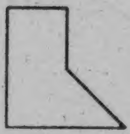

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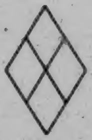

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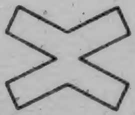

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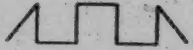

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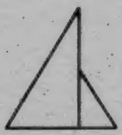

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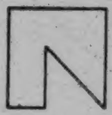

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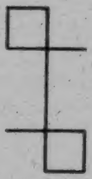

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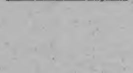

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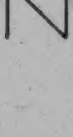

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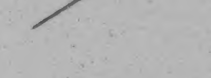


APPENDIX K

Auditory-Visual Coding (AVC) - Schematic Representation[1]

Examples

i) x x $\underline{a}$ b c
ii) x x x   a $\underline{b}$ c
iii) x x x   a b $\underline{c}$

Test Items

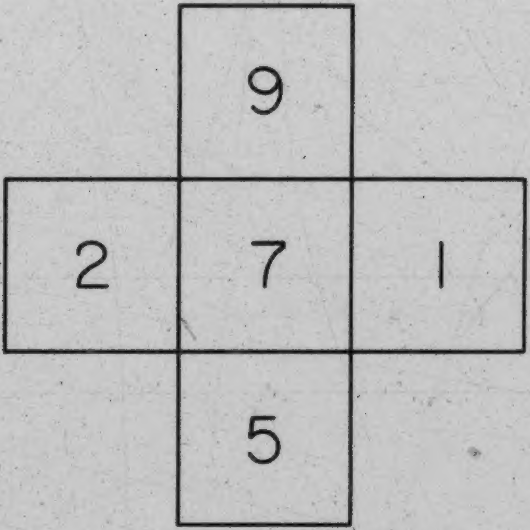
1. x x x x $\underline{a}$ b c
2. x x x x   a $\underline{b}$ c
3. x x x x x $\underline{a}$ b c
4. x x x x   a b $\underline{c}$
5. x x x x x x   a b $\underline{c}$
6. x x x x x   a $\underline{b}$ c
7. x x x x x x   a b $\underline{c}$
8. x x x x x x x $\underline{a}$ b c
9. x x x x x x   a $\underline{b}$ c
10. x x x x x x   a $\underline{b}$ c

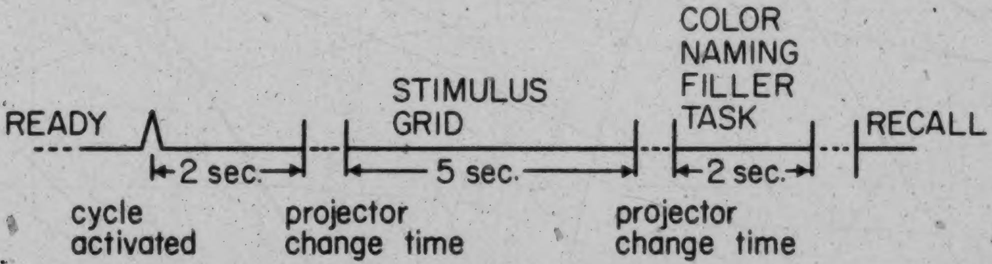
---

[1] Crosses represent 1000 Hz. discrete tones of 0.2 sec. duration with a short pause (shown as short gap) of 0.4 sec. and a long pause (shown as long gap) of 1.2 sec. The underlined letter represents the corresponding visual dot patterns presented in the order a, b, c as shown.

APPENDIX L

Visual Short-Term Memory Task (VSTM)[1]




READY
cycle activated
2 sec.
projector change time
STIMULUS GRID
5 sec.
projector change time
COLOR NAMING FILLER TASK
2 sec.
RECALL

---

[1] Diagram showing sample visual short-term memory (VSTM) task grid and operation. VSTM items on next page.

VISUAL SHORT-TERM MEMORY TASK

Example:	Read as:	Example:	Read as:
9 845 1	84591	9 631 5	63195

(1)	2 497 1	(2)	7 239 6	(3)	7 529 4	(4)	4 893 1
(5)	5 481 6	(6)	9 753 1	(7)	3 561 8	(8)	7 398 4
(9)	3 869 4	(10)	5 361 9	(11)	6 329 5	(12)	2 359 6
(13)	8 165 3	(14)	1 358 9	(15)	2 458 1	(16)	8 365 1
(17)	1 563 8	(18)	5 923 6	(19)	4 592 7	(20)	6 924 5

APPENDIX M

Auditory Serial Recall Task (ASR)

Acoustically Similar Words

Examples: a. big long great tall
b. cow day key few
c. man mad map pan

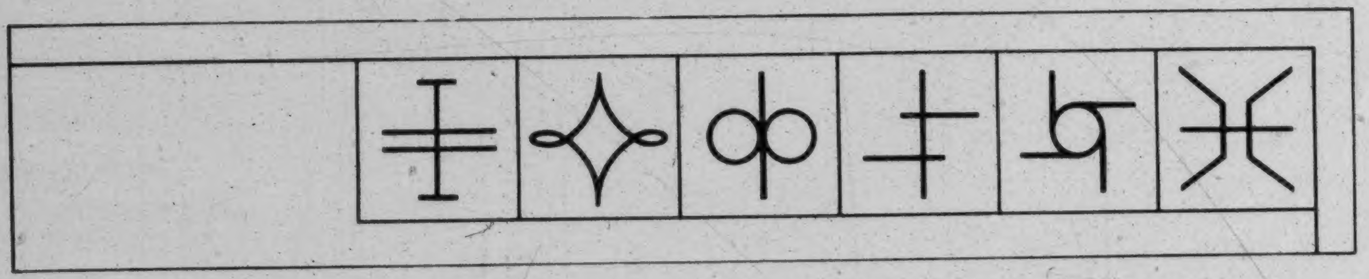
Test Items

1. key hot cow pen
2. cab cat mad can
3. day cow wall bar
4. man mad pan mat
5. pen wall book key
6. book bar wall hot
7. key few hot book
8. can pan tap cab
9. tap mat pan cat
10. key day cow bar
11. cab cap cat tap
12. bar pen few day
13. cab man mad map
14. mat can cap man
15. few pen hot wall
16. day cow bar wall
17. cap pan cat can
18. man mad mat pan
19. few day cow book
20. cap man mad tap
21. key book day hot
22. cab tap man cat
23. can cap pan mad
24. pen few wall cow

Rest for about 60 seconds

APPENDIX N

Sample Item (No. 17) from Illinois Test of Psycholinguistic Abilities Visual Sequential Memory Subtest[1]



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[1] Chips on plastic tray placed facing the child as shown.

APPENDIX O

Illinois Test of Psycholinguistic Abilities Auditory Sequential Memory Subtest (AM)

Basal: 3 consecutive successes
Ceiling: 2 consecutive failures

*DEMONSTRATION

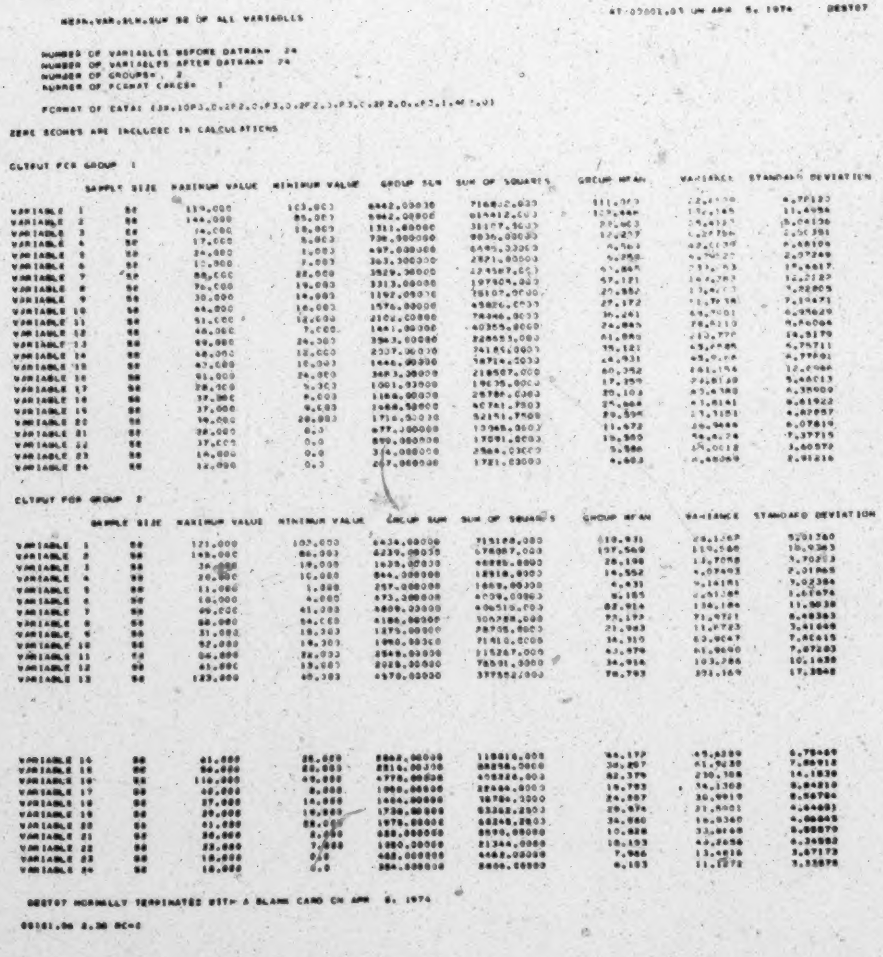
a. 2-2
b. 2-1

Test Items

		1st	2nd
1.	9-1	___	___
2.	7-9	___	___
3.	8-1-1	___	___
4.	6-4-9	___	___
5.	5-2-8	___	___
6.	2-7-3-3	___	___
7.	6-3-5-1	___	___
8.	8-2-9-3	___	___
9.	1-6-8-5	___	___
10.	4-7-3-9-9	___	___
11.	6-1-4-2-8	___	___
12.	1-5-2-9-6	___	___
13.	7-3-1-8-4	___	___
14.	5-9-6-2-7	___	___
15.	7-4-8-3-5-5	___	___
16.	2-9-6-1-8-3	___	___
17.	5-2-4-9-3-6	___	___
18.	4-7-3-8-1-5	___	___
19.	6-9-5-7-2-8	___	___
20.	3-6-1-9-2-7-7	___	___
21.	5-3-6-9-7-8-2	___	___
22.	8-1-6-2-5-9-3	___	___
23.	2-7-4-1-8-3-6	___	___
24.	4-9-6-3-5-7-1	___	___
25.	3-1-9-2-7-4-8-8	___	___
26.	9-6-3-8-5-1-7-2	___	___
27.	4-7-3-1-6-2-9-5	___	___
28.	8-2-5-9-3-6-4-1	___	___

APPENDIX P

Descriptive Statistics for Experimental Group (Group 1) and Control Group (Group 2)[1]



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[1] Variables: 1 = chronological age; 2 = Lorge-Thorndike Non-Verbal IQ; 3 = Raven's Coloured Progressive Matrices; 4 = Figure Copying; 5 = Memory-for-Designs; 6 = Auditory-Visual Coding; 7 = Visual Short-Term Memory; 8 = Auditory-Serial Recall; 9 = ITPA Visual Memory; 10 = ITPA Auditory Memory; 11, 12, 13 = Dichotic "Sides"--free, serial, free and serial scoring respectively; 14, 15, 16 = Dichotic "Types"--free, serial, free and serial scoring respectively; 17, 18 = Dichotic Ear Order left and right respectively; 19, 20 = Dichotic Attempted Ear Order left and right respectively; 21, 22 = Dichotic left and right ear recalled first; 23, 24 = Dichotic left and right ear recalled second.

VITA AND PUBLICATIONS

VITA

(to July, 1974)

NAME:	Che Kan LEONG
CITIZENSHIP:	British Subject (Canadian Landed Immigrant)
YEAR OF BIRTH:	1931

POST-SECONDARY EDUCATION AND DEGREES:

Northcote College of Education, Hong Kong
1951-1953 Teacher's Certificate

University of Hong Kong, Hong Kong
1954-1957 B.A. (Hons.)

University of Queensland, Brisbane, Queensland, Australia
February-December, 1960 Post-Graduate Dip. Ed. Psych.
Dissertation: A Study in Prediction of Secondary School Success

University of Hong Kong, Hong Kong
1961-1964 (part-time) M.A. (Ed.)
Thesis: An Experimental Study of Attitudes and Abilities of Trainee Teachers and their Significance for Teaching

University of Alberta, Edmonton, Alberta, Canada
1972-1974 Ph.D.
Thesis: An Investigation of Spatial-Temporal Information-Processing in Children with Specific Reading Disability

HONOURS AND AWARDS:

Hong Kong Government Scholarship tenable at University of Hong Kong
1954-1957

UNESCO Fellowship in Educational Psychology and Child Guidance tenable at Queensland University and Australia
February, 1960-July, 1961

Canada Council Doctoral Fellowship tenable at University of Alberta
1972-1974

RELATED WORK EXPERIENCE:

Secondary School Teacher, Un Long Public Middle School, Hong Kong
1953-1954

Lecturer in Educational Psychology, Northcote College of Education,
Hong Kong, 1957-1965

Visitor to Various School Psychological Services in Australia
January-July, 1961

Education Officer, Research, Testing and Guidance Section,
Education Department, Hong Kong, 1963-1968

Acting Senior Education Officer, Research, Testing and Guidance Section,
Education Department, Hong Kong, January-July, 1969

Assistant Professor, Institute of Child Guidance and Development,
University of Saskatchewan, Saskatoon, Saskatchewan, Canada
July, 1969 to to-date (July, 1974)

RECENT PUBLICATIONS (to July, 1974)

I. Chapters in Books

1) "Language Behaviour of Moderately Mentally Retarded Children". In Das, J.P. and Baine, D. (Eds.) Mental Retardation for Special Educators. Springfield, Illinois: Charles C. Thomas (in Press).

2) "Aspects of Diagnosis of Mentally Retarded Children". In Das, J.P. and Baine, D. (Eds.) Mental Retardation for Special Educators. Springfield, Illinois: Charles C. Thomas (in Press).

3) "Reading in Chinese with reference to Reading Practices in Hong Kong". In Downing, John (Ed.) Comparative Reading: Cross-National Studies of Behaviour and Processes in Reading and Writing. New York: Macmillan, 1973, 383-402.

4) "A Follow-Up of Early Entrants to Elementary Schools" with J. McLeod, D.M. Markowsky. In Johnston, B. (Ed.) Education Yearbook, 1973-74. New York: Macmillan, 100-105.

II. Papers in Journals

1) "If the Model Fits - an Analysis of the Revised Illinois Test of Psycholinguistic Abilities for Moderately Mentally Retarded Children and Implications for Language Programming". The Slow Learning Child, (to appear in July, 1974).

2) "Aspects of Reading Difficulties". Journal of Education, Chinese University of Hong Kong, May, 1973, 4, 91-104.

3) "An Oblique Glance at Reading Disability". The Orton Society Bulletin, 1972, 22, 69-79.

4) "A Follow-Up of Early Entrants to Elementary Schools" with J. McLeod, D.M. Markowsky. The Elementary School Journal, Oct., 1972, 73, 1, 10-19.

5) "Programming for Trainable Mentally Retarded School Children". The Slow Learning Child, July, 1972, 19, 2, 102-108.

6) "Physical Activities for Mentally Retarded School Children" with J. McLeod, J.A.G. Gittins. The Slow Learning Child, March, 1972, 19, 1, 40-52.

7) "A Study of Written Chinese Vocabulary". The Modern Language Journal, April, 1972, LVI, 4, 230-234.

III. Booklet/Papers Read

1) "Everybody's Child: the Mentally Retarded". Tape-slide-print project for Institute of Child Guidance and Development, University of Saskatchewan, Saskatoon, Canada, 1972, pp. 68.

2) "Language Differences and Reading Disabilities". Paper read at the Symposium "Comparative Reading", International Reading Association 17th Annual Convention, Detroit, May, 1972.

3) "A Strategy for Transcultural Studies of Early Reading in the Alphabetic and Ideographic Systems". Paper read at XIII Inter-American Congress of Psychology, Panama City, Republic of Panama, December, 1971.

IV. Forthcoming Papers

1) "Dichotic Listening and Cerebral Specialization Revisited with Dyslexic Children". Invited feature paper to be read at the World Congress on Dyslexia (Mayo Clinic and the Orton Society), Rochester, Minnesota, 9th November, 1974.

2) "Comparison of Languages in Early Reading". (In preparation, 1975).

3) "Psycholinguistic Abilities of Moderately Mentally Retarded Children". Paper to be read at the Council for Exceptional Children 53rd Annual International Convention, Los Angeles, 25th April, 1975.